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STEEL CASTINGS.

ON THE USE OF STEEL CASTINGS IN LIEU OF IRON FORGINGS AND BRASS CASTINGS IN BUILDING AND FITTING SHIPS, ETC.*

By Mr. E. C. WARREN.

THE short paper which I am about to read will, to a considerable extent, express the united opinion of the committee upon the use of steel castings for Her Majesty's service, with which I was lately connected; and I have permission to use such portions of that report as may, in my opinion, be necessary to place this subject fairly before you.

The proper value of steel castings is not sufficiently understood by shipbuilders, engineers, and other manufacturers who work in metals; it seems to me that a more intimate acquaintance with their value for many purposes, and especially as a substitute for iron forgings and brass castings, and even in lieu of iron castings where strength and lightness have to be considered, will before long bring about a very great change, and the more steel castings are used the more will they be appreciated and sought after, provided that a fair price be paid, and an honest material be supplied by the manufacturer.

Castings in steel are generally made from crucible or open hearth steel; but there are some makers who use steel of special manufacture.

The points which I propose to consider are:

1. What success has, up to the present time, been obtained in producing steel castings for use in lieu of iron forgings?

2. What description of articles usually made of forged iron, or brass castings, could with advantage be made of cast steel; having regard to weight, strength, and durability?

3. What tests should be applied to various descriptions of steel castings?

With regard to the first point, I can confidently state that very great success has already been obtained in producing steel castings in lieu of iron forgings: this opinion has been formed after visiting a large number of the principal steel foundry works in England and Scotland; and in carrying out a series of exhaustive tests especially with small castings. See Appendix I., and the diagrams annexed, which illustrate samples of one of the series of tests so carried out.

The small articles selected for testing purposes were:

1. Clips for water tight doors.
2. Eyeplate, 1 in., for use on iron beams, etc.
3. Pivot bar for 20 pounder gun.
4. Clips for securing chains for 6 in. breechloading and other guns.
5. Hooks for tackle blocks.
6. Internal binding for 10 in. snatch block, and swivel hook.
7. Internal binding for 10 in. treble block, swivel eye, and shackle.
8. Deck plate with double eye and links for securing guns.
9. Fighting pivot for 64 pounder and 7 in. guns.
10. Longitudinal intercostal angle 3 in. by 3 in. by $\frac{7}{16}$ in., long 3 ft.
11. Bedplate for Nordenfelt gun.
12. Intercostal beam angle 3 in. by 3 in. by $\frac{3}{8}$ in., long 2 ft.
13. Intercostal angle 3 in. by 3 in. by $\frac{7}{16}$ in., long 2 ft. 6 in.
14. Boat's crutch.

In addition to these, a great number of larger steel castings were examined and tested, viz.:

a. Stems for ships of various sizes.
b. Stern posts for "
c. Stern frames for "
d Rudders for "
e. Brackets for supporting after ends of propeller shafts.
f. Dredger chains and buckets.
g. Hawse pipes.
h. Anchors.
j. Frames for gun carriages.
k. Saddles for gun carriages.
l. Main bearing frames for engines.
m. Crank shafts.
n. Wheels of all sizes.
o. Cylinders.
p. Propeller blades.
q. Rudder frames.
r. Caps for masts and bowsprits.
s. Riding bitts.
t. Capstans.
u. Cable holders.
v. Deck pipes and plates.

Appendix II., with its illustrations, gives sketches to scale of some of the articles previously enumerated, and also the tests to which they were subjected.

These speak for themselves as to the difficulty of making perfectly sound and reliable castings for the articles shown; but the difficulty existed only to be overcome, and no one could see the splendid specimens of castings which were turned out, and which stood most satisfactory tests, without being convinced that in cast steel we have a material which, although only partially developed, is of the utmost value. We want the ability and determination of the makers and the intelligence and skill of the workers combined, to still further develop and perfect this branch of manufactures.

I think a similar process will have to be gone through with steel castings as that which took place with respect to the manufacture of mild steel for plates, etc., a few years since, and which has produced such great results that mild steel plates, angles, etc., are now produced at prices which were not then thought of, and of such excellent quality and homogeneity that we may almost say we possess a perfect article at a most moderate price.

When the same process has been passed through for steel castings, a great deal of inferior make will disappear, like the old steel plates which would break up like a sheet of glass if they were let fall upon an iron slab, and we shall get an article in every way reliable, at a greatly reduced price.

It is found that small castings made from good crucible steel are remarkably tough, ductile, and of uniform quality, while many of those made from other steels are very unsatisfactory, and unfit substitutes for small iron forgings.

For large articles, good, sound, reliable castings can be made, with proper care, from either crucible or open hearth steel.

With regard to the second point, viz., What description of articles usually made of forged iron, or brass castings, could with advantage be made of cast steel, having regard to weight, strength, and durability? It is, I think, evident that the question of cost will largely determine the extent to which steel castings are brought into use; for small articles, where only a few of one description are wanted, it will be cheaper, and a saving of time, to continue to make them of forged iron; but even for very small fittings, where large numbers of similar patterns are required, the saving by using cast steel will be very considerable, both in time and money.

For larger articles, such as stems, stern posts, brackets for supporting propeller shafts, rudder frames, racers for guns, frames for water tight doors, trolleys for machine guns, hawse pipes, etc., the saving would be very great indeed.

Appendix III. gives a list of such articles or parts of a ship, or her fittings, which could be advantageously made of cast steel.

The strength of good steel castings is beyond question, and their durability is very great, and the saving in weight is very considerable.

I have seen small steel castings which have been in every respect equal to the best iron forgings; but I am also bound to say, that I have seen others which could not be safely used on board ship, or in any position where they would be subject to shocks or vibrations, and the greatest care is required in selecting and testing steel castings before they are accepted.

There are steel castings and steel castings, good, bad, and indifferent, and the price paid will often, to a great extent, determine to which category the articles belong. I am certain that, even at the present time, a fair price paid to any of our well-known steel founders will enable us to obtain sound and reliable castings, which will bear the most rigid examination and tests.

Too often prices are cut down to such an extent that the temptation to use inferior materials is irresistible, and when such is the case the usual results follow, and there is a failure. Thus it is we so often hear of steel castings having failed, and so an undeserved slur is thrown upon the manufacture.

There are some well-known firms who are too high minded to allow any but the very best materials to be used, and the result is that their castings are almost uniformly of the highest character, and none but the best are allowed to leave their works.

It is to makers of this type that we must look for improving and cheapening the cost of steel castings. At the present time every effort is being made by most able and skillful men to investigate the nature and combination of metals, both scientifically and practically, and the trained chemist is standing by to watch, and work out carefully the results; and it is to be hoped that before long we shall be able to produce perfect steel castings at a most reasonable cost.

This brings us to a most important point of our subject, viz.:

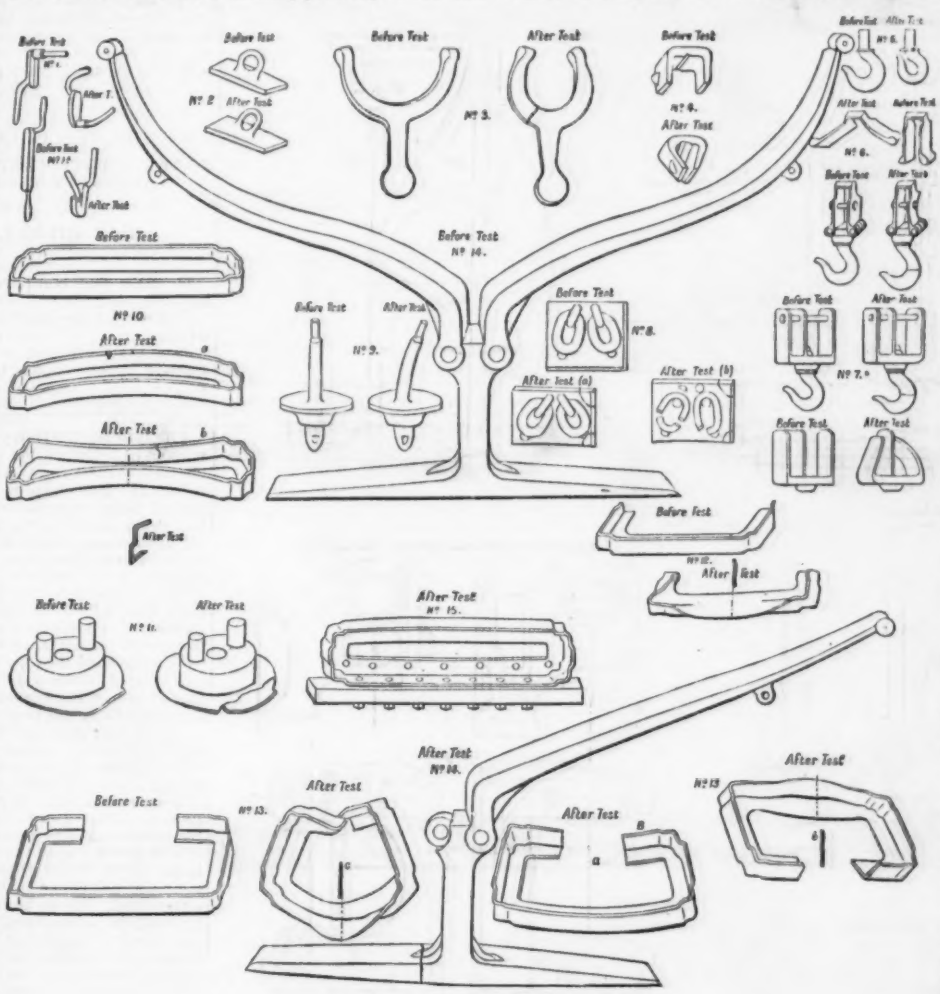
What tests should be applied to various descriptions of steel castings?

It is extremely difficult to lay down any general law on this point; steel castings are used for so many purposes, involving entirely different conditions, according to the nature of the work required for them, that the tests which are absolutely necessary to be obtained in some cases may be dispensed with in others.

In Appendix III. is given the list of fittings proposed to be cast in steel, and also the tests which it is considered should be applied to each.

The appearance of the fractures of broken castings gives also certain indications of the nature of the materials. The percussive test is most valuable where it can be applied; and it is most desirable that when a number of articles, or fittings, of the same or similar patterns are supplied, a test to destruction should occasionally be made, to obtain information from time to time, as to the ultimate strength of the castings.

I consider it undesirable, and unnecessary, to specify



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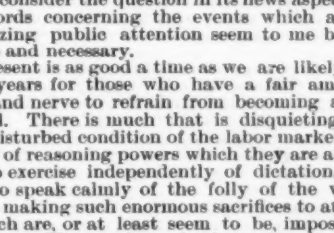
* Paper read at the twenty-seventh session of the Institution of Naval Architects, London, May 1886.

a minimum and maximum tensile strength per inch; if the minimum be given, and the elongation in a given length, and a bending test, together with a percussive test, where such may be applicable, it is sufficient to insure perfectly reliable articles.

It is a well-known fact that some steel which will bear a greater tensile strain than the maximum specified will, notwithstanding, show excellent results of elongation and bending; and when this is the case, to insist upon its rejection because of its superior strength would be unreasonable; and as a matter of fact—having obtained the minimum tensile test to insure sufficient strength—the elongation and bending tests should determine the question as to receipt or rejection.

I should like to make reference briefly to some steel castings which were cast at Stockholm by Nordenfelts' patent process; they were most interesting, and of superior finish, and they could be bent and twisted cold in an extraordinary manner without fracture. A



specimen given by Mr. Nordenfelt, with permission to test it in any manner desirable, gave the following results, viz.:

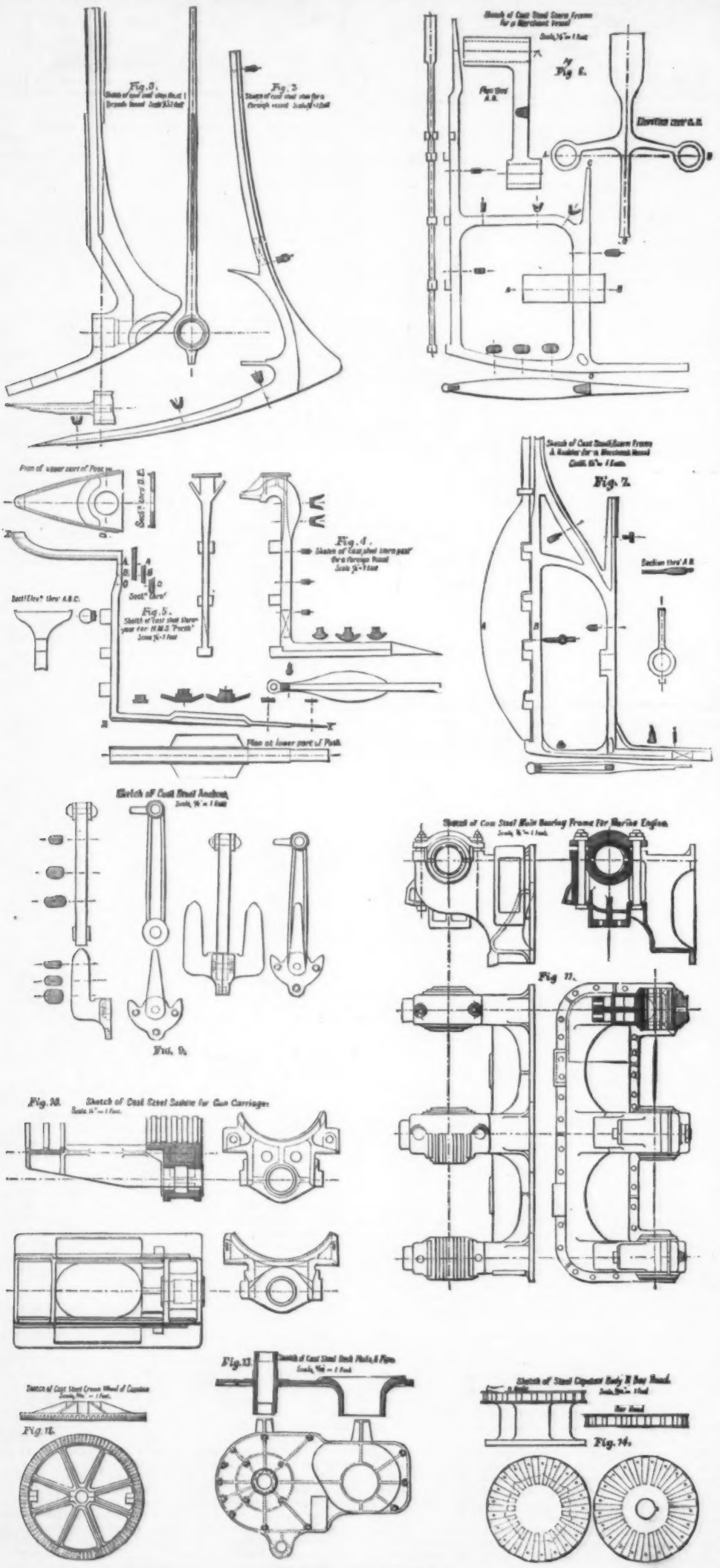
Tensile test. 28 tons per square inch.
Elongation in 2 in., 12·8 per cent.

I am of opinion that if castings by the Nordenfelt process can be produced at a reasonable cost, they will be of very great value in lieu of small iron forgings and brass castings.

It will be observed that I have not dealt with chemical tests for steel castings. I attach very great importance to the labors of the chemist in relation to the manufacturer; but I do not attach any value to the chemical tests which are sometimes insisted upon before castings are accepted by the purchaser.

The large variations in the results of tests obtained by different chemical manipulators are most perplexing, and in my opinion they may be safely neglected, the mechanical tests previously named being amply sufficient to meet every possible requirement.

(To be continued.)



STEEL CASTINGS.

SIBLEY COLLEGE LECTURES.—IX.

BY THE CORNELL UNIVERSITY NON-RESIDENT LECTURERS IN MECHANICAL ENGINEERING.

By JAMES C. BAYLES.

THE RIDDLE OF THE SPHINX.

II.

DURING the comparatively brief interval* since I had the pleasure of addressing you upon certain historical phases of the labor question, so much has happened that probably the conclusions I shall present to-day will be very different from those I should have considered it my duty to present three months ago. Events move rapidly in times like these. Titanic forces take birth and exhaust themselves almost before one can study their phenomena.

The late A. L. Holley was once asked why he did not write a great work on steel, which should perpetuate his well-earned reputation; and replied, in effect, that before the last chapter went to press, the first chapter would need complete revision, and the man who bought it would have to hurry home with it, lest it should become obsolete on the way. It is so with the discussion of the labor question. Three months ago nothing would have seemed more improbable than a strike, without redressible grievance to excuse it, stopping the traffic on hundreds of miles of railroad, with rioting, bloodshed, and the wanton destruction of property, by a branch of an order pledged to seek by every peaceful means an amicable adjustment of all differences between employers and wage-earners. But just this has happened, from causes easily explained after the fact, but impossible of prediction. Fortunately, however; there are broad principles underlying all the relations of capital and labor, which are not touched by local and temporary conditions. I shall not attempt to consider the question in its news aspects; but a few words concerning the events which are now monopolizing public attention seem to me both appropriate and necessary.

The present is as good a time as we are likely to see in many years for those who have a fair amount of courage and nerve to refrain from becoming alarmed or excited. There is much that is disquieting in the present disturbed condition of the labor market. Men possessed of reasoning powers which they are able and willing to exercise independently of dictation, find it difficult to speak calmly of the folly of the working classes in making such enormous sacrifices to attain results which are, or at least seem to be, impossible of attainment. Those whose business is stopped, or threatened with stoppage, because of impracticable demands made on behalf of the labor unions, find it difficult to look beyond their immediate environment. They see that the men with whom they have had long and satisfactory relations yield a blind obedience to a power which is eager to lead them into trouble, but cannot stand between them and the consequences of their own mistakes. All this is very discouraging, but the teachings of human experience during centuries are not likely to be contradicted by the happenings of this year or next. Organized labor cannot accomplish impossibilities. The more it wastes its accumulated earnings in strikes and demonstrations, the more it dissipates the power it has for blocking the wheels of industry. The sharper the conflict it invites, the sooner will the issue be tested and the more decisive the result.

The eight-hour movement is just now the leading issue. The test strikes brought in different parts of the country to show the power of new organizations representing the workingman have failed. The Knights of Labor permitted the Southwestern railroad strike to become what in law would be called "a test case." Their absolute and unconditional defeat was evident from the outset. A score of trade unions have since made a decisive issue of the eight-hour demand. No one need fear that this demand will be enforced where the conditions are not such as to permit the requirements of the market to be met by a production possible in eight

* For preceding—introductory—lecture, see SCIENTIFIC AMERICAN SUPPLEMENT, April 10, 1886, No. 586, p. 9357.

hours of each day. Whatever concessions organized labor may wring from employers which diminish the supply and enhance the cost of articles of general consumption will be but temporary, and the equilibrium will restore itself after a very brief period. It is also well for those who are seriously alarmed to remember that only a very small percentage of the labor of the country is organized, and that of this percentage a yet smaller fraction demands a shortening of the hours of labor. It is true that the minority has an undue measure of influence, wholly disproportionate to the numbers it represents, but such influence evaporates rapidly. It is no more possible to carry a labor movement against public sentiment than it is to carry an election against public opinion—not so much so, indeed. An election can be "carried" by fraud in voting or counting, but a labor movement which attempts to run counter to public sentiment cannot avail itself of any such expedients. Public sentiment does not sustain the present attitude of organized labor nor approve its demands. When this fact is fully recognized, as it must be before long, the eight-hour movement will die a natural death, and a great many unions will die with it.

The industrial crisis through which we are passing is not the first we have experienced, nor by any means the worst. By midsummer it is likely the strike fever will have run its course, and the delirium have given place to rational thought and reflection. The resources of labor are limited. It cannot stand the present drain upon reduced wages, especially when it becomes known that of the money contributed to sustain strikes, the strikers get very little. The competition of men who must have work is being felt more keenly every day by men who think they can afford to stand idle. A mob may close the way for a day or a week, but an army could not keep hungry men with hungry families from the employment which awaits them. The more general the substitution of men willing to work for men anxious to strike, the more absolutely organized labor cuts itself off from its base of supplies.

There need be no alarm as to what will come of it all. So much of that demanded by labor as can be secured and held belongs to labor; so much as fails of accomplishment is not as yet its right. In some trades eight hours may be the maximum of a man's efficient service. In others it is not, and never will be until machinery is abolished and men have to again resume the burden it is now carrying. The laws of trade cannot be set aside arbitrarily. Out of the confusion of the moment order will come, and order represents the normal operations of law. General prosperity is already in sight, and in the disappointment of its present plans labor will find a satisfaction it does not now look for. When manufacturers organize, and deal with great trade problems on a statesmanlike basis, it will be found that many of the demands of labor are less unreasonable and impracticable than they appear to the individual employer, called upon to decide them without knowing how his competitors will decide. In his enthusiasm for organization the employer of labor can afford to get excited, but in everything else he would do well to remain cool, deliberate, and diplomatic. The world is not going all to pieces. No breach of business is likely to be materially or permanently injured. Seed time and harvest will follow one another in regular succession, and, if less is consumed this year, more will be needed next. Ninety-nine per cent. of the people of the country are pursuing their ordinary avocations, knowing and caring very little about what the other 1 per cent. are doing, saying, or planning. We do not know just how the tangled skein will unravel itself, but it certainly will, and no one will gain anything by losing his head.

In my first lecture I endeavored to show what forces are operating to cause discontent among the working classes, and what organized labor demands of society. My present task is to show, as well as I am able, how such of these demands as are reasonable and proper can best be met by providing the agencies of self-help. I think it may be assumed that there is no problem in sociology which cannot be solved; but the conditions favoring its solution may not be found to exist under a system of government consistent with political liberty and popular representation. Probably no question presents more difficulties than that of bettering the condition of that substratum of society, the idle, vicious and willingly dependent poor, who gravitate into mendicancy and crime, and have no desire for anything better or different.

Schemes of self-improvement do not include this class, and as the recipients of a great deal of a false quality of sympathy, they are, to an injurious extent, shielded by public sentiment from the penalties which society should visit upon those who elect to be degraded. But even this class can be reached, and by proper measures lifted out of the mire and made industrious, self-sustaining and grateful. Count Rumford's experience in this department of philanthropy is so interesting and instructive that I should be glad to review it in outline, but as it is found in the life and writings of that wonderful man, I must refer you to these for particulars.

If, however, the task of reaching and improving the condition of the lowest element of society has been found possible of accomplishment, no one should deem impossible the elevation of those inspired by an honorable and proper ambition to take advantage of all the opportunities of self-improvement which may be offered. The fact that labor is organized and is moving steadily, and in the main intelligently, for the accomplishment of the ends it seeks, warrants the belief that it would work out its own salvation in a comparatively short time, if a termination of the conflict between capital and labor could be effected in an alliance for mutual advantage.

We hear and read a great many platitudes on this subject. A certain class of writers tell us there is no conflict between capital and labor; that their interests are common, and that neither is in a position to oppress or wrong the other, owing to the intervention of natural laws. We also hear a great deal of the same kind of talk about the conflict of science and religion. Many good and conscientious men tell us that there is no conflict between them; but there is, and has been ever since scientific investigation begun to cast doubt upon the infallibility of theological interpretation, and probably it will continue so long as science is progressive and theology conservative.

The conflict between labor and capital will also continue so long as capital and labor are governed by considerations of narrow selfishness, and remain blind to the larger considerations of enlightened self-interest. The organization of labor has for its immediate object nothing else than a more effective resistance to the effort of capital to press to the bitter end the advantage it has over labor without organization. No truce will be reached until capital shall ask it on honorable terms.

Strikes may be lost or won, trade unions strengthened or dissolved; but the conflict will continue a war in which nothing is so disastrous as victory except defeat. But through organization labor is learning a great deal, and its present general line of policy indicates a growing appreciation of the value of a peaceful and mutually satisfactory adjustment of differences.

What is the issue involved in this conflict between labor and capital? In my judgment, it is the protest of the burden bearer against fictitious capital. If it be true, as I am more than willing to admit, that labor has no quarrel with the capital actually invested in the machinery and appliances of useful production, I can easily see that it has a perfectly just grievance in the demand of fictitious capital for interest to be paid before labor can share the earnings of productive or distributive industry. There are very few enterprises conducted by joint stock companies which are not watered more or less heavily.

An investment of $50,000 is often a sufficient foundation for capitalization on a basis of $500,000 or more. Millions have been added in a day to the capital of companies enjoying valuable public franchises, simply because the franchises are valuable. Often this is done to conceal earnings. In the elevated railroads of New York we have a case in point. The right of stock to earn interest is pleaded as an excuse for opposing a reduction of fares at all hours to five cents; but when it is remembered that a very large part of the stock is fictitious, and was created for the purpose of concealing what would otherwise have been unreasonable earnings, the man who pays a ten cent fare has a right to feel that he is robbed. The same is true of Western Union, and to my knowledge is true of a great many manufacturing companies, and of nearly all railroads. The employer who makes a large profit has a right to take it out of his business or leave it in; but if he increases his capital stock to conceal the earnings of his real capital investment in times of prosperity, he furnishes labor a just cause of complaint if, in times of depression, he cuts down wages that this fictitious capital may earn interest. And yet this is the rule rather than the exception.

Labor will have a righteous quarrel with capital so long as it demands for each honest dollar invested the interest upon two dollars. This is not a new proposition, but it accounts for much which those representing capital profess themselves at a loss to understand.

And now we reach the great question to which all that I have thus far said is but introductory and explanatory. How can the reasonable demands of labor be satisfied, and the wage earner made to feel that his industry and skill are fairly and satisfactorily compensated by his share of the profits of production? To this all discussion of the labor question inevitably leads. I approach it modestly, but with entire confidence that he who seeks the answer with honest purpose will not fail to find it. I do not think it will be found by labor in co-operative production. This, however, depends upon what is meant by co-operation.

If it means the co-operation of capital and labor on the basis of enlightened self-interest, the plan is feasible and desirable. If, however, it means the competition of labor with capital through the formation of many small manufacturing companies of workmen, the remedy will be found of very limited application, at best. I have very little faith in this form of co-operative production It tends steadily toward an end which may be reached at once by means of stock companies. No successful business can long continue on a co-operative basis.

As the original shareholders die, their interests revert to non-producers. In fifteen or twenty years the whole character of such a corporation will necessarily have changed, and by the concentration of control in the hands of a few, labor will be excluded from participation in ownership or management. This cannot be averted under other than exceptional conditions. The original shareholders will rarely agree to any plan of organization providing that, at their death, their shares shall revert to surviving members. The tontine feature does not admit of application to this class of undertakings.

Clever and ambitious mechanics will not risk their savings and time without an individual ownership in the shares they help to make valuable. They work for the future, and the desire to leave an estate, great or small, is strong in the heart of every self-respecting man with wife and children. The mechanic who helps to establish a co-operative enterprise has a faith in its future which justifies present risks and sacrifices; but he will not make these sacrifices unless they be for his own benefit and he have an inalienable interest in the future of the enterprise—for himself if he lives, for his heirs when he dies.

I know of a dozen co-operative manufactories which, in less than half the limit of possible life on their original basis, have passed into the hands of individuals not connected with them at the outset, and the wage earners employed in them have no interest in their profits. Participation is practicable and desirable under favorable conditions; co-operation, using the term in its accepted significance, is, in my judgment, a system which will rarely be found practicable, for the reason that economical production is inconsistent with the indefinite multiplication of small industries. It has been suggested as a means of averting the concentration of shares that, on the death of a member, his share could be appraised and sold for the benefit of his heirs to one who would take his place as a workman. If the share is valuable, a workingman could rarely command the purchase money. If he has to borrow it, he must pledge his share as collateral, which he could not do if it were not salable in open market and transferable without conditions. I see no way in which co-operation on this plan can be made practicable as a means of benefiting the working class, although it sometimes operates most beneficially in advancing the interests of ambitious and enterprising workingmen who have a talent for organization and management, and who are willing to make their own interests paramount to those of their associates.

I do not believe that the end sought will be reached by anything which seeks to introduce new social conditions. I have already alluded to the great industrial establishment at Guise. It is one of the most interesting social experiments now in progress in Europe, and claims somewhat careful attention. The Guise works, in the Aisne department, France, formerly belonged to M. Godin, and are still under his immediate charge. In 1859 Godin put up a large building, called the "*familistere*," for the accommodation of 300 families, adding a theater, school-house, etc. Twenty-one years later he extended his scheme, bringing forward the co-operative plan, which is interesting as a striking departure from similar experiments made elsewhere.

The Societe du Familistere de Guise is composed of the founder, M. Godin, and of four classes of employes, members, associates, participants, and interested parties, whose rights and qualifications are defined as follows in the by-laws: The founder reserves the right to accept or reject any applications for admission to any one of the different classes, and of granting applications, even if certain qualifications are not complied with. He has the power to designate his successor during his lifetime or by testament. He has power to propose modifications of the by-laws, even without the written consent, otherwise required, of two-thirds of the members. This power does not, however, descend to his successor, nor does the acquirement by inheritance of founder's shares entitle the owners to any of the founder's rights, or confer on the heir or heirs authority to meddle with the affairs of the association. It carries with it simply the enjoyment of the proper share of the profits. "Members" must be at least 25 years of age, must have resided at least five years in the "familistere," and have worked during at least the same period in the shops of the company. They must be able to read and write, and must be owners of at least 500 francs' worth of the company shares. They have the first right to employment, and in times of scarcity of work are entitled to a certain share in the profits, and are members of the assembly. "Associates" must be at least 21 years of age, be residents of the familistere, and have a record of three years' work with the company; while the "participants" must have served the company for a year, but need not be residents. They, too, share in the profits, and take precedence in employment in case of short work. "Interested parties" are those who have acquired shares by purchase or inheritance. They draw interest to the extent of five per cent. on their capital, and share in the net returns. The interest on capital is paid in cash, the profits of labor are paid in certificates of savings of 50 francs each. In case of the death of an employe whose heirs are not members of the association, his certificates will be redeemed at one-half of their face value, the other half being paid to the benefit funds. The "members" belong to the general assembly, which elects three members of the managing committee, of which the founder and general manager is president, and the six chiefs of departments are members. The general assembly receives the report of the general manager, and has a voice in matters touching the purchase or sale of plant, the raising of money, and all extraordinary expenditures. The general manager has the sole right to sign in behalf of the association, and is its representative. The general assembly elects three persons from its number, who constitute the supervising committee, the duties of which are to examine books and to take part in the annual examination of the inventory. There are, besides, two other minor committees, the one having charge of the familistere, and the other deliberating on all industrial questions.

From the returns at the end of the fiscal year, 10 per cent. is first written off from the value of the material, and 5 per cent. from the value of the plant; then the grants to the benefit funds, the cost of education and instruction, and the interest on founder's and savings shares. The balance is the net profit, which is distributed as follows: Twenty-five per cent. goes to the reserve fund and for the purchase of shares, and 50 per cent. to capital and labor; that is, labor is represented by the total wages earned during the year, and capital by the interest on capital and savings shares, the dividends on capital being payable in cash and the dividends on labor in savings shares. Out of the remainder, 12 per cent. is given to the general manager, 9 per cent. to the members of the council, 2 per cent. to the supervising committee, and 2 per cent. is for distribution among those employes who have distinguished themselves by exceptional services. In the allotment to the workmen, the "members" are entitled to a share measured by twice the amount of their wages, the "associates" by one and one-half times their wages, and the "participants" by the exact amount of their wages. Losses are borne by the reserve fund, and, when the latter is exhausted, by assessments. Roughly, therefore, after providing for a reserve fund, the profits are divided into three parts—one of them, the smallest, going to capital, in the form of cash; the second, the largest, going to labor in the shape of interest-bearing savings certificates; while a full third is devoted to compensation for services of administration.

The workings of the plan thus far have been quite satisfactory. In 1880, the association assumed the Guise and Laeken-les-Bruxelles works and the familistere buildings, put up in 1859, the patterns and patents, for 2,288,383.44 francs, the raw material and stock at 1,956,012.17, and cash and funds to the value of 356,604.39 francs, a total of 4,600,000 francs, or more than a million of dollars, as the capital of the founder. The employes, numbering 1,022, did not put in anything but their skill as workmen and their good will; now, the men possess shares or certificates of savings representing a capital of 1,969,000 francs, and in from 12 to 15 years they will be the proprietors of the entire establishment. It may be urged that this is certainly an extremely handsome showing for the men, but that it is not likely to be very encouraging to other employers to follow this example. Still, M. Godin has had a very good thing of it. Practically, he is selling his works to his men, instead of allowing it to pass by purchase into other hands and taking the risks from which he is now secured. The men have acquired a share of the profits amounting substantially to 12 per cent. of the total amount of their wages, which goes into capital ac-

count and draws interest in succeeding years. Besides this, the laborer has an interest in three societies, one an insurance fund for the necessities of life, another against infirmity or old age, and the third against sickness. The first is mainly provided for by the payment of a sum equal to two per cent. of the wages by the association, its object being to contribute to the necessities of members, even when capable of working, when their income is insufficient. The sums vary from 1 to 2·5 francs a day for men, and from 0·75 to 1·5 francs a day for women, according to length of service. The third fund is maintained by the employes by the payment of 1·5 per cent. From this it will be seen that the Guise experiment is based upon an elaborate system of which I have simply given the rough outlines. Its main principles are the dwelling together of the workmen in one large building; a progressive grading of participation in the profits of the work, represented by the acquirement of a growing interest in it; the comparatively small share of capital in the profits, and the large amount paid to management.

The more carefully and critically the Guise enterprise is examined, the more we discover the reasons for doubting that it could, with advantage, be imitated in its essential features as a socialistic experiment. There are two sides to the picture. Godin built up the great business now in part turned over to his work people, by good management and enterprise. It could have been built up only under individual control; and had it started as a co-operative venture, with many heads, it would probably never have reached great proportions or importance. As a financial enterprise it is a success, but as a socialistic experiment it cannot be so regarded. Godin provided model lodging-houses, restaurants, baths and schools where the workmen can get all the comforts of life cheaper than the discomforts of life cost them outside. In spite of the attractions and advantages offered by this "social palace," as it is called, a majority of the workmen prefer the freedom of their own more expensive and ill-kept homes; and the founder has said that he regrets having made his experiment with such dull and unpromising material as the workmen of Guise, who are, it must be admitted, deficient in point of intelligence. But in spite of these drawbacks something has been accomplished. Such a thing as a strike has never been known at Guise, the business has been uniformly prosperous, the workmen are better paid, better housed and in better condition every way than they would have been if M. Godin had been a mere capitalist intent on selfish enrichment; but the vital question is, Is the arrangement permanent? No one familiar with the facts so considers it.

A single incident shows that the success of the experiment so far has been the result of a commanding intelligence controlling the whole scheme, and that even among workmen trained by years of experience in the benefits of co-operation the selfish instinct of immediate individual gain overpowers the desire for a remoter gain through the general well-being. Some time ago a rule was drawn up enacting that an allowance out of the general fund should be made to all workmen who fell ill and could not work. This allowance was to be paid from the day the illness began. Shortly after this had been decided upon, the committee found the number of illnesses increased in a most suspicious manner, and the relief fund diminished rapidly. A new rule was made, providing that no allowance for sickness was payable till the patient had been ill three days. The new arrangement had a miraculous effect upon the health of the *familistere*, and the fund was soon as large as ever. Seeing this, the committee reverted to the original rule, of course with the same result as before. The relief fund dwindled rapidly; and for the sake of the workmen's health—not to speak of their morality—it was judged advisable to abandon the immediate relief plan.

One such incident sets aside the whole experience of years in the attempt to establish human relations on any other basis than that of self-interest. When we speak of an enlightened selfishness as the basis of society, we may rest assured that the measure of enlightenment in the selfishness will be the measure of enlightenment in society, and there is no existing society in which the wage-earning class is sufficiently enlightened to carry on with success such a project as the kindly, generous heart of Godin has devised. There is no use in sentimental regrets over the failure of experiments carried on under conditions which render success impossible, and the failure of the Guise *familistere* will merely prove that Godin was too early with his reform. If we were to seek a law or formula by which to describe the inevitable failure of such experiments, we might say that in a condition of society in which they are practicable they will not be needed; or, we might say that workmen intelligent enough to profit by them will be, and are, intelligent enough to get along quite as well without them.

The world has furnished a good many examples of more or less successful attempts in the same general direction as that at Guise. We cannot, however, spare time to consider them. I think that such lack of success as has attended them has resulted from a mistaken philanthropy, which has sought to provide the workingmen something they do not want. Habits of life are not easily changed, nor are tastes once formed easily forgotten when opportunities for more elevating pleasures are offered. For the reason that Godin regrets that his experiment was made with such unpromising material, others will have reason to regret that their schemes of large and unselfish philanthropy contemplated the welfare of a class of people who prefer absolute freedom from the necessary restraints which life, under refining and elevating conditions, imposes upon those thus brought together. Mr. Andrew Carnegie, in a lately published review of the labor question from an employer's standpoint, says: "There are, of course, a few successful establishments, notably two in France and one in England, which are organized upon a co-operative plan, in which the workmen participate directly in the profits. But these were created by the present owners, who now generously share the profits with their workmen, and who are making the success of their manufactories upon the co-operative plan the proud work of their lives. What those concerns will become when the genius for affairs is no longer with them to guide, is a matter of grave doubt, and to me of foreboding. I can, of course, picture in my mind a state of civilization in which the most talented business men shall find their most cherished work in carrying on immense concerns, not primarily for their own personal aggrandizement, but for the good of the masses of workers engaged therein and their families; but this is only a foreshadowing of a dim and distant future. When a class of such men has been evolved, the problem of capital and labor will be permanently solved to the entire satisfaction of both. But as this manifestly belongs to a future generation, I cannot consider co-operation, or common ownership, as the next immediate step in advance which it is possible for labor to make in its path upward."

I do not think the best interests of labor will be accomplished by providing the working classes with attractive and comfortable surroundings in advance of their demand for them. We have in Pullman, Ill., a very interesting experiment of this kind, which does not promise as well as could be wished. Pullman is unique among cities, and it is probably the most costly and interesting social experiment ever tried in this or any other country. It has sprung into existence with a rapidity which would have been impossible anywhere else. One can scarcely realize that such completeness could have been attained within three years. It is a delightful surprise; but there remains another surprise which shall involve the success or failure of the social experiment there working out its doubtful solution. It is as an experiment that I shall consider it.

During a recent visit to Pullman I had an opportunity of seeing a phase of its social life which is not usually shown to visitors, and in which it is not probable a majority of them feel much interest. I refer to the rears and insides of the mechanics' dwellings. The system of sanitary policing which maintains the cleanliness of streets, side-walks, and front doors, extends to back yards and interiors as well. The dwellings of the mechanics are neat, wholesome, and attractive, and it cannot for a moment be doubted that those who live in Pullman are more comfortable in all respects, and can purchase with the fruits of their labor better living accommodations, better and cheaper food, better facilities for the education of their children, better amusements and better surroundings in all respects, than they could elsewhere. But it is unfortunately true that those most directly and immediately benefited by such a system are most restive under its restraints and conditions. Those who gain most from the enforcement of rules insuring cleanliness and healthful conditions are, of course, those who would naturally incline to dirt and squalor, and it is these who yield a reluctant compliance to the rules which demand that they shall live decently and free from nuisances of their own or their neighbors' making. It is obviously true that the suppression of all traffic in intoxicating liquors is attended with benefit to the entire community, and especially to the wives and children of those who would naturally incline to gratify a vicious appetite for drink at the expense of a larger share of their earnings than can be spared without the sacrifice of necessities and comforts; but those to whom such restraints are most beneficial chafe most under them, and are most inclined to resent them as an interference with the exercise of their rights as citizens of a free country. It is the same with the food distribution system of the city. The careful surveillance which is at all times maintained over the marketmen and shopkeepers of Pullman effectually protects the consumer against overcharge, and excludes from the stocks offered for sale anything not conforming to the best standards of quality; but it is probable that a majority of those who are most benefited as consumers chafe under the oversight exercised in their interest, and feel impatient of the paternal relation which the company's agents maintain toward all who reside in the town. It is because the town of Pullman is the same from all sides as from the point of view occupied by the casual visitor, and because the system which seeks to make life comfortable for the townspeople is thorough and comprehensive, that it offends so many and creates so much discontent. At the same time it must be admitted that without just such a system the experiment must necessarily fail; with it success, though not yet assured, is, perhaps, possible.

One who has had no practical experience with undertakings having for their object the advantage of the working classes, would naturally imagine that the marked contrast between life in a town like Pullman and that in the crowded streets and bad neighborhoods of our manufacturing cities, would make the former wholly acceptable to the average workingman. But the average workingman does not reason very closely. He resents anything like an interest in his behalf, and is at all times suspicious of everything which savors of philanthropy. That which is given him he despises; that which he must purchase, if better or cheaper than he is accustomed to, he is suspicious of. He does not, and perhaps will not, understand that a capitalist can have any other object in life than to exact the last farthing of profit from him, both as a producer and as a consumer, and such conveniences as a free library, a bright and beautiful reading-room, a charming theater where the best classes of amusements are furnished at prices below those charged in the meanest variety shows of the cities, seem to the average workingman as so many juggles to entrap him into yet more complete dependence upon his employers. He wearies of enforced morality; he becomes restless in the presence of restraints; and he is very apt to cultivate a wholly unnatural and unreasonable desire for things he cannot have, and which, if he had them, he would loathe and seek escape from. It is just this unreasonable impatience of wholesome rules and good influences which make so many of the residents of Pullman discontented, and eager to get away when the opportunity for work is offered elsewhere. They know they are better off in Pullman than they would be anywhere else, but they object to being benefited against their will, under a system which prescribes what is best for them without consulting their preferences. The incentive to self-improvement is withdrawn; they would be better with more of self-dependence.

Under almost any other conditions than those which exist at Pullman I should despair of the success of the experiment. Fortunately, the company owning the town have a basis of permanence in their plant and investments. If the shops continue in successful operation, in time the venture will become so firmly established that it can defy adverse conditions. The shops will gradually attract a class of workmen who appreciate the advantages of a system insuring health, comfort, and good moral surroundings. The discontented and restless will go away and better men will take their places. Those who elect to stay there will be the ones to whom rules and regulations requiring cleanliness and good habits will be welcome safeguards against conditions they are glad to escape from. If this expectation is realized, it will bring the Pullman Company a superior class of workmen, and will thus prove the wisdom of their experiment, regarded from the standpoint of self-interest. I expressed these views to an intelligent mechanic employed by the Pullman Company, and he rather startled me by asking, "Would you advise a young man to locate in a town of 6,000 inhabitants, which had a bonded debt of $13,500,000, on which 6 per cent. interest is demanded?"

Regarded from this standpoint, I had to confess the belief that I should consider my own chances of prosperity better where the burden was lighter.

Those who honestly desire to promote the welfare of labor, will do well to recognize that all forms of social progress are of comparatively slow development, and that families unfitted by education and habit for the enjoyment of refined pleasures, or incapable of the personal sacrifices demanded of those who live under conditions at once agreeable and elevating, must be left to live as suits them best until such time as the impulse to better their own condition shall seize them. The city of Hygeia will remain a dream until we shall find a community loving cleanliness and abhorring dirt. So it is with the model community of workingmen. Good society is impossible without good materials out of which to organize it. The pleasures and occupations of people of refined tastes are impossible to those whose tastes are not refined. As the rule, the wage-earning classes do not appreciate nor desire such accessories of comfortable living as model houses, public libraries, instructive lectures, superior entertainments, good music and enforced abstinence from beer and spirits. Such surroundings impose unwelcome conditions. They do not breathe freely, and are not, generally speaking, sufficiently unselfish to consent to the subordination of their own tastes and preferences that their children may learn to enjoy surroundings tending toward mental and moral improvement. What then are the conditions and limitations of practical effort to improve the condition of the working classes, allying capital and labor and putting an end to the conflict of selfishness in which capital and labor have both suffered so heavily?

The most intelligent students of the industrial problem seem to be of the opinion that the only way in which results satisfactory alike to labor and capital, and beneficial to society, can be reached is by the establishment of a partnership between the employer and the workman, on the basis of a division of profits which shall be equable and just. The propriety of such a partnership will be the more evident if we dismiss from mind the false assumption which has so long held its ground as a basis principle in political economy, that the wage of labor is paid out of the capital of the employer. Henry George, in his incisive work on "Progress and Poverty," shows very clearly what all employers of labor have known practically, that product and not capital pays wages, and that in proportion to its productiveness, labor is entitled to a larger or smaller compensation. Obviously, I cannot stop to seek exact definitions nor to guard every position with argument and statistical proof. I must remain content with stating conclusions as clearly and specifically as possible, leaving those whom I address to confirm or contradict them by subsequent thought and study. The writer of books has no excuse for being dogmatical, but it may be pardoned in a lecturer who seeks to cover a great deal of ground in a few minutes.

From long intercourse with masters and men, I have reached the conclusion that the fundamental mistake of our present industrial system, and the source of nearly all the well grounded complaints of labor, is found in the averaging of wages, and in the failure to recognize men as other than units of equal value. Labor is in some degree responsible for this; certainly it has emphasized it by a system of organization which assumes that the skillful and industrious should surrender something of their advantage that those less useful in the world may demand a larger share of the profits of production than they would be able to command, if left to make their own bargains with employers for exchanges of work and wages. In encouraging this system of dealing with men as of equal value and agreeing with labor upon an average wage which is less than the value of one class of men and more than that of another, the employer usually serves his present convenience in simplifying his book-keeping and facilitating his calculations of cost, at the expense of the larger benefit which would result to him from a cordial co-operation of labor in his plans and undertakings, and the maintenance of relations of harmony and good will with those with whom such an alliance would be advantageous.

If the intelligent employer of labor, with a fixed plant, and measurably constant requirements as to the number of hands needed, will carefully study his own business, and analyze the elements which, in their aggregate, constitute his manufacturing costs, he will find that a considerable percentage, larger or smaller according to circumstances, represents waste. Materials are wasted, time is wasted, tools and plant are wasted, and the cost of his product has to bear it all. In proportion as he can prevent waste, he diminishes the charges against the product which reduce his share and that of labor. Waste benefits nobody. If it can be prevented or reduced to a minimum, it is obvious that his share and that of labor can both be increased. Good system and constant vigilance will accomplish this in part, but not so thoroughly as it is accomplished by giving labor a pecuniary interest in the results of a close economy of time and material. Looking yet closer, he will discover that his working force may be divided into classes. In one class he places those of superior fidelity, who can be trusted under all circumstances; in another class he places men of superior skill and intelligence, who are capable of rendering yet more efficient service, but who seem to lack the incentive; in another he places the average steady man, who does his work in a way to merit neither praise nor censure; in another he places those who are of no particular value, but are probably as efficient and industrious as the average of those who could be hired in their places. Perhaps he may make still another class, which will include those whom he will select for discharge if his interest or convenience

suggested a reduction of his force. Now, in reasoning upon the results of his observations, he would conclude that to pay the men in these several classes a given rate of wages was unfair. So it is, but how shall the injustice be rectified? The first and most natural answer to this question would be that he recognize the superior value of the men he grades the highest by increasing their wages. To this course there are several practical objections. Primarily he cannot afford to do so. His manufacturing costs are now as high as those of his competitors, and if his product was burdened with yet heavier labor costs, he could not sell it in competition with other manufacturers in the same line. Again, to advance the wages of some and not of all would create dissatisfaction among those discriminated against, and might demoralize his whole establishment. If he could preserve his present average labor cost by reducing the wages of those least efficient, and increasing the wages of those most efficient, he would accomplish exactly what his sense of justice would approve; but this is impossible. His entire force would probably strike. Supposing such a condition of affairs to exist, it is likely the manufacturer would call into his office for conference the men he had intended to advantage, and point out to them the folly of their course in depriving themselves of a substantial good for the sake of averting from those who merit no such consideration the proper consequences of their inefficiency and lack of ambition. If, among the men thus addressed, there was one who knew how to express himself and set forth the claims of labor, he would probably reply: "You do not see why we, who are offered an advance of wages, should object to a reduction in the wages of others who, we admit, are not as good workmen as we are. I will tell you why. Our interests are wholly with labor. It suits your present purpose to advance our wages. The union does not object to that, nor do we. To do it, however, you propose to reduce the wages of men who, like ourselves, must live. Suppose we consent; we cut ourselves off from the fellowship, sympathy, and support of the union, and are properly regarded as traitors to the principles we are pledged to maintain. Consider the position in which this places us. Organized labor no longer stands behind us to defend our rights when menaced. For the increase you offer we place ourselves at your mercy; and if it pleases you to reduce our wages one-half three months or six months hence, we must accept the reduction or stand idle. We are workingmen. The instinct of self-preservation prompts us to stand by our fellow workmen. We are much obliged to you, sir, for your desire to help us; but if this can be accomplished only at the expense of men to whom we owe a loyal support, we must decline it. We are sorry to strike, and shall be yet more sorry if you think us ungrateful or insensible of your goodwill and appreciation; but until we have a closer alliance with capital than an increase of wages offers, we must decline to sever our alliance with labor, which has, for years, protected us against the selfish greed of capital."

If the employer receiving this explanation was a thoughtful man, with average reasoning powers, he could not fail to recognize the force of the argument and the wisdom of the men in preferring the fellowship of labor to the advantages of an increase of wages. What had he offered them as compensation for the surrender of those advantages which labor had conquered at a cost so great? What pledge dare he give them that is worth as much as the knowledge that, in their hour of need, labor will stand by them, prepared to make any sacrifice to shield them from injustice and oppression? In the case we have imagined the employer had the right idea, but before that idea can be carried out, capital will have to form a partnership with skill; and until this is brought about, labor will prefer the alliance it now has. Probably this can best be effected by some system of profit-sharing, by which those entitled to it shall receive, in addition to wages, a proportion or percentage of the net earnings. The higher the average wage under these circumstances, the less the amount which can be divided as profit between employer and workmen—a fact which, by bringing the element of selfishness into the problem, will ultimately tend to ally with the employer those who are in a position to derive least benefit from the sympathy and co-operation of organized labor.

Industrial partnerships are beginning to attract a good deal of attention. Col. Carroll D. Wright, Chief of the Bureau of Labor Statistics, has prepared a valuable monograph on profit-sharing, which reviews the whole subject with great clearness, and gives the history of every experiment of this kind of which there is a record. The paper was published in the Seventeenth Annual Report of the Massachusetts Bureau of Statistics of Labor, and separately as a pamphlet of 83 pages, which all who are interested in this subject would do well to procure. It is a most instructive little work, and a reference to it is of more value for the student than would be such a synopsis of its contents as is possible in the few minutes at my command. I may say in passing, however, that I consider profit-sharing the best solution of the labor question yet proposed. How and on what basis its profits shall be shared must, in each instance, be determined with reference to the conditions actually existing at the time and place. Perhaps the most valuable of the conclusions to which my study of the labor question has brought me, is that society has no use for doctrinaire solutions of the great social problem. That I have no theory to offer for your consideration, and no faith in any one else's theory to express, is, perhaps, due to the fact that for some twenty years I have been brought in contact with many lines of business, and have learned from observation how infinitely various are the conditions which make up the relations between employers and wage-earners. I am not, however, without certain well-grounded beliefs—or to be more accurate, well-established doubts—some of which may be stated:

I do not believe that the organization of labor will have any other permanent good effect than to bring about an alliance between honest employers and faithful workmen; and I do believe that in accomplishing this, labor organizations will die.

I do not believe that society is ready for any radical change in the existing basis of industrial organization. The inequalities which exist among men cannot be obliterated by any human agency so long as some men have the capacity for organization and management, while others have not. Those who have will be employers, and those who have not will work for them. In the remote future all this may be changed, though nothing warrants the hope that it will be. I believe, however, that enlightened self-interest will more closely unite successful employers and trustworthy servants, and that the ambition of the workingman will be, not be control or coerce capital, but to ally himself with it.

Notwithstanding the capacity of labor for vast sacrifices, I do not believe that the several classes of wage earners can long remain united. The sacrifice demanded of those who are skillful and faithful is out of all proportion to that made by the masses of those who feel that the end and aim of life is to sell the least service for the most money. One class of workmen will ally itself with capital; the other class, lacking the moral and material support of those who now give the trade unions whatever dignity they possess, will give up the unequal contest, and every intelligent workingman's ambition will be to rise to the class which is independent of the help of trade unions.

I believe that this will come about as soon as employers recognize that self-interest prompts them to seek an alliance with labor on the basis of a more equitable participation in the profits of production than the wage system offers. Until then we may expect such disturbances as we are now witnessing. Have you ever asked yourselves, Why is it that skillful mechanics and men better than the average of their fellows obey the orders of a rattle-brained demagogue like Martin Irons, or why a walking delegate, himself unknown, and of no possible consequence industrially or socially, can walk into a mill, and, by holding up his finger, compel every man in it who works for wages to follow him out of the door? There is but one possible explanation of this phenomenon. Where there exists between employer and workman such a relation as is easily possible, and has been formed under a thousand different conditions, the walking delegate would be collared by indignant workmen and landed on the sidewalk. It may require a generation to establish such a relation, and occasional happenings seem to contradict the belief that it is possible at all, but self-interest will triumph in the end as surely as gravitation will sooner or later pull down the one stone that is laid upon another.

The great subject so imperfectly presented and discursively treated in this lecture is one which may well claim the study and thought of every young man fitting for the practical duties of life, and soon to take his place among the representatives of the aristocracy of education, upon whom will devolve the duties and responsibilities of command and direction. No human man can assume these duties and move among his work people without feeling that he owes them an obligation other and greater than can be discharged weekly at the pay window. The industrial system in which we are captains and lieutenants holds them inexorably in the ranks, while to us all the avenues of promotion are open. If the great problem of the improvement of the condition of the working classes is ever to be solved, we whose minds are trained to logical and purposeful thought, and who control the machinery of capital, must at least help solve it. For the idle and vicious there is nothing but the bitter fruits of idleness and vice. Those who break the inflexible laws of Nature must expect to incur her inexorable penalties, and it would be a false and hurtful philanthropy which should seek to avert them. But for industry and thrift there should be something better than our present industrial system gives. Arbitration should decide fairly and impartially the issues between workman and employer, and some part of the profits of production should seek investment in ways which will react favorably upon the interests of labor. Participation should be established on an equable basis as the reward of faithful service, and co-operation should be promoted wherever and whenever it can benefit the wage-earners. What may be our duty in these directions depends upon what may be our opportunities. Wise leadership and direction for the labor movement will come, if at all, from the men of education who are carrying on for capitalists or corporations the productive industries of the country. The doctrines promulgated in the several schools of political, economic, and Christian socialism are well worthy our careful and thoughtful study. Properly understood, they are full of suggestions for the man who has the love of his fellow men in his heart. Misunderstood, as they are likely to be by the average wage-earner, they are as flaming brands thrown among inflammable material.

To lead wisely and successfully the great movement which seeks the greatest good of the greatest number, we must disabuse our minds of the mistaken idea that in the simple expedient of "Be it enacted" we have a panacea for all evils. Rather are we likely by this means to create new and yet graver evils. We should also understand that it is impracticable to assume the paternal relation toward the wage-earner. Most philanthropic schemes have failed because conceived in pure benevolence. Self-interest must provide the means; self-help must employ them. The problem presented to enlightened philanthropy is to provide the ladder by which those who will may climb high enough to enjoy, not the bounty of charity, but some substantial good which they have acquired by the practice of those sturdy virtues which have ever been promotive of individual welfare and the good of society.

One may well be distrustful of everything in the shape of off-hand solutions of a problem so complex and profound as that to which I have called attention. Each of us for whom it has a direct and personal concern must study it from his own point of view. He has little reason to hope that, like Œdipus in the fable, he will guess this riddle; but that he can do something to establish more cordial relations between labor and capital, and to create that community of interest which long ago ceased to exist between them, is more than probable. My own idea of the first step in this direction should be a more conspicuous recognition of individual worth and capacity. Obviously, it is the interest of capital to hold out all reasonable incentives to those who have the ambition to rise above the average of their fellows, by making such self-advancement profitable. In no other way can the ambition of young men in the ranks of labor be quickened than to open for them a way in which they can secure, as the reward of zealous and intelligent service, an alliance with those who represent the power of capital. What should be the second step would depend very much upon conditions necessarily local and, perhaps, temporary. I do not doubt, however, that, wherever the desire exists to do something for the benefit of labor, the means will suggest themselves in conference with those in the ranks of the workingmen whose counsel may be sought with advantage. We may dismiss from our minds all the dreams of the advanced socialists, and venture no impracticable experiments. We need recognize no rights as belonging to the working classes other than those which enlightened self-interest prompts us to concede. But within this safe territory of the practicable and the expedient, we can find many opportunities for broad and intelligent philanthropy, which will be fruitful of good results in readjusting the relations of capital and labor upon a safer and more satisfactory basis of peace, prosperity and contentment.

THE COLORATION OF WINES.

By P. CAZENEUVE.

I HAVE the honor of presenting a general method, and a sure and exact one, of characterizing those coloring matters (fuchsines, etc.) which are now so much employed, and which are more or less immediately derived from coal. This method is based upon the use of metallic oxides, properly so called. I have tried in particular yellow oxide of mercury, moist hydrate of oxide of lead, and gelatinous hydrate of peroxide of iron.

The coloring matter of wine, which is a sort of tannin, is a weak acid that forms, as well known, soluble lakes with a large number of metallic salts, such as those of lead, mercury, iron, and others. The excess of these salts, however, either redissolves the metallic lake or acts upon the foreign, artificial, coloring matters. It occurred to me that the direct intervention of the oxides of these metals, which are weak and insoluble bases, might fix the normal coloring matter of wine, without exerting any destructive action with respect to the majority of the coal tar colors, and without forming combinations therewith; and this view was confirmed by experiment. The following are the facts:

A. Yellow Oxide of Mercury.—Hot or cold, yellow oxide of mercury holds back the normal coloring matter of wine, as it does also the color of cochineal and the vegetable coloring matters used for wines, and that, too, perfectly. About 0·20 gramme (3 grains) of the salt is sufficient to decolorize 10 cubic centimeters (0·00176 pint) of wine.

Cold or hot, it allows to pass, through filtration, the sulpho-conjugate derivative of fuchsine, even when there are but traces; and also the following coloring matters: Bordeaux red B, soluble red (sodic salt from the sulpho-conjugate derivative of rocelline), purple red, croceine 3 B, scarlet (Biebrick red), crimson R, crimson B, orange R, RRR, H, and RR, tropeoline M and II, yellow I, fast yellow, binitronaphthol yellow, and yellow NS.

These colors wholly pass, even when they are contained in but small quantities. The yellow oxide seems to hold back a portion of the following colorings: orange I, saffronine, chrysoidine, chrysoine, methyleosine, yellow II, red NN and I, and crimson RR. It holds back erythrosine, eosine J, methylene blue, Coupier blue, and diphenylamine blue.

All these experiments, like the following, were performed with small quantities of the coloring matter, representing a quarter, and often less, of the coloring matter of the wine. They were always performed with wine, as the conditions of the medium change the reaction. Thus, erythrosine, which passes in aqueous solution, is held back when wine is the solvent. As to heating, the liquid simply was raised to ebullition.

B. Hydrate of Oxide of Lead.—The hydrate used contained 50 per cent. of water to the proportion of 2 grammes (15 grains) per 10 cubic centimeters (0·017 pint) of wine. Cold, it holds back the normal coloring matter of wine, when shaken for a minute or two. Hot, it suffices to bring to ebullition. All the vegetable colorings, as well as cochineals, are likewise held back.

This oxide, contrary to what occurs with oxide of mercury, allows the fuchsines to pass very well. I have tried the hydrochlorate, sulphate, acetate, oxalate, and arseniate of rosaniline. The filtered liquid is acidified in order to regenerate the rosaniline salt completely. It lets pass orange I (with rosy tint), saffronine, orange R, orange RRR (with rosy tint), tropeoline M and II, chrysoidine, chrysoine, orange II, methyleosine, fast yellow, binitronaphthol yellow, yellow NS and I, and crimson B. It partially holds back eosine J, yellow II, red I, and crimson RR.

Like oxide of mercury, it totally holds back methylene blue, Coupier blue, diphenylamine blue, and erythrosine; but, unlike oxide of mercury—and the fact is remarkable—it holds back the sulpho-conjugate derivative of fuchsine, Bordeaux red B, purple red, and insoluble rocelline red.

Gelatinous Hydrate of Peroxide of Iron.—The oxide employed contained 90 per cent., about, of water to the proportion of 10 grammes (150 grains) per 10 cubic centimeters (0·017 pint) of wine. The mixing was done cold, and the liquid brought to a boil. Pure wine was thoroughly decolorized. Cochineal and the vegetable coloring matters were held back.

The following colors pass: erythrosine (which is held back by the oxides of lead and mercury), the sulpho-conjugate derivative of fuchsine, Bordeaux red B, purple, soluble red, and fast yellow. On the contrary, all the fuchsines other than the sulpho-conjugate derivative are held back. The other, and less important, coloring matters have not as yet been examined.

Stannous hydrate and zinc hydrate gave encouraging results. Certain coloring matters pass, while others are partially or totally fixed, with a formation of variously, and often characteristically, colored lakes.

We here at once see a possible general method of either distinguishing or separating these coloring matters. A comparison with a type solution, the dyeing of silk and wool, then a reaction of concentrated sulphuric acid, spectral action (Girard and Pabst), and solubility in amylic alcohol, will permit of ascertaining their nature, etc. I may say, apropos of this, that the hot treatment of wine by magnesia and amylic alcohol permits of isolating and distinguishing a large number of artificial blues that are held back by the oxides of lead, iron, and mercury.

I even hope to generalize the method, and succeed in distinguishing the natural coloring matters from each other. I would mention stannous hydrate as easily

holding back the coloring matter of wine, and letting cochineal and cudbear pass.

From wine there is but a step to recover the artificial coloring matters in sirups, liqueurs, and other food products.—*La Nature.*

ON DISSOCIATION TEMPERATURES, WITH SPECIAL REFERENCE TO PYROTECHNICAL QUESTIONS.*

By FREDERICK SIEMENS.

IN bringing the subject of dissociation before the Royal Institution of Great Britain, the author proposed to confine himself to its influence on combustion and heating, that is to say, to its effects on combustible gases and the products of combustion, and on furnace work generally. His researches had been made for the most part in connection with large gas furnaces constructed according to his new system of working with radiated heat, or what may be otherwise called free development of flame. In the first or active stage of combustion the flame passed through a large combustion chamber (all contact with its surfaces being avoided), and parted with its heat by radiation only; while in its second stage the products of combustion were brought into direct contact with the surfaces and materials to be heated, by which means the remainder of its heat was abstracted. This, in a few words, was a description of the method of heating with free development of flame. In perfecting this system of furnace, the principle of which was in many respects the reverse of that generally accepted, both as regards construction and working, he had to examine into the accuracy of certain scientific theories which could not be brought into harmony with the actual results he obtained.

Adopting the generally accepted theory of combustion, according to which a flame consists of a chemically excited mixture of gases, whose particles are in violent motion, either oscillating to and from each other or rotating around one another, it followed that any solid substance brought into contact with gases, thus agitated, must necessarily have an impeding effect on their motion. Motion being the primary condition of combustion, the latter would be more or less interfered with, according to the greater or less extent of the surfaces which impede the action of the particles forming the flame; in the immediate neighborhood of such surfaces the combustion of the gases would cease altogether, because the attractive influence of the surfaces would entirely prevent their motion; farther off, their combustion would be partial, and only at a comparatively great distance the particles of gas would be free to continue unimpeded the motion required to maintain combustion. On the other hand, the surfaces themselves must suffer from the motion of the particles of gas producing the flame, for, however small these particles might be, they produce, while in such violent motion, an amount of energy which, acting constantly, would in time destroy the surfaces opposed to them, just as "continual dropping wears away stone." This circumstance fully accounted for the fact that the inner sides of furnaces, and the materials they contained, were soon destroyed, not by heat, but by the mechanical, and perhaps also by the chemical, action of the flame. It would seem strange that the heating power of a large volume of flame should be so much interfered with by the contact of its outer parts only with the inner sides of a large furnace chamber, if there was not another cause besides imperfect combustion to reduce the heating effect of a flame which touched the surfaces to be heated. A flame when in a state of combustion radiated heat not only from its outer surface, but also from its interior, by allowing the heat to radiate through its mass. In this manner every particle of flame sent its rays in all directions, but if the flame itself touched anywhere combustion ceased there, free carbon was liberated and produced smoke which enveloped that part and prevented the rays of heat of the other portions of the flame from reaching it.

The author had avoided for various reasons referring to the subject of dissociation until recently, although it had been brought forward by several writers, and used as an argument against his new system of furnace; as according to these writers it would appear to be impossible to produce such exceedingly high temperatures as he claimed to reach. He had long held the opinion that appearances of dissociation not being observable in furnaces heated by radiation, but occurring in furnaces in which the flame was allowed to come into contact with surfaces, must be due to the action on the flame of those surfaces at high temperature. He was led to this conclusion partly from his own observations, and partly from descriptions of dissociation observed by others, among whom was his brother, the late Sir William Siemens, who described a case of dissociation (see lecture delivered March 3, 1879, at the Royal United Service Institution, entitled "On the Production of Steel, and its Application to Military Purposes") which occurred in a regenerative gas furnace constructed according to their old views of combustion and heating. *The conclusion at which he had arrived was, that solid surfaces, besides obstructing active combustion, must also, at high temperatures, have a dissociating influence on the products of combustion.*

In order to obtain information on this subject he examined the laws and theory of dissociation, and endeavored to bring the various results obtained by scientific authorities into agreement with one another, and with his own experience, but failed entirely in doing so. The temperatures of dissociation of carbonic acid and steam, the two principal gases forming the products of combustion when ordinary fuel was used, vary very much according to these observers, and the results he had obtained in practice were different from most of them. He hoped to prove that the temperature at which dissociation sets in is, in most cases, much higher than generally admitted; and that the authorities he was about to refer to had omitted in almost all the experiments they had made to take into proper consideration one element which was liable to alter materially the results obtained by them. *This element was the apparatus used for those experiments as regards its surface, form, and material.*

In considering the question of dissociation, he proposed to commence with Deville, who first discovered and called attention to the dissociation of gases at high temperatures. He made numerous experiments with various gases, and fixed certain temperatures at which he found that either complete or partial dissociation took place. Without going into details, he might mention that Deville required to use vessels and tubes of definite dimensions, material, and structure, in order to obtain the results stated. One experiment had to be made with a porous tube, another required the use of a vessel with rough interior surfaces, or containing some rough or smooth material. In this way Deville arrived at a great variety of results, and although he did not state that the rough surfaces, or porous tubes, or the solid material placed inside the vessels which he employed, had any particular influence on the temperature at which dissociation took place, yet it would appear that he could not obtain his results without having recourse to those means. Deville's results depended very much upon the various kinds of surfaces he used in his experiments, if they were not entirely brought about by them; these experiments, moreover, were of a very complicated nature, so he proposed to pass on to more modern authorities, whose experiments were of simpler character, and less open to objection.

The most important experiments which modified those of Deville were due to Bunsen. Bunsen observed the dissociation of steam and carbonic acid by employing small tubes filled with an explosive mixture of these gases, to which suitable pressure-gauges were attached. On igniting the gaseous mixture, explosion took place, and a high momentary pressure was produced within the tube; from the pressure developed, Bunsen calculated the temperature at which the explosion took place, and found that it varied with the mixtures employed. He records the circumstance that only about one-third of the combustible gases took part in the explosion, from which circumstance he concluded that the temperature attained was the limit at which combustion occurred. To prove this, Bunsen allowed the gases sufficient time to cool, after which a second explosion was produced, and even a third explosion when time was allowed for the gases to cool down again. Bunsen obtained much higher temperatures for his limits of dissociation than other physicists; these were for steam about 2,400° C., and for carbonic acid about 3,000° C. These temperatures were probably higher than are reached in the arts, as materials used in furnace-building would not withstand such temperatures for any length of time; but still he must call attention to the circumstance that if the influence of the inner surfaces of the tubes on the combustion of the gases therein could be removed, the dissociation temperatures arrived at would be found still higher. He could not admit that Bunsen's explanation of the cause of the second and third explosions was quite satisfactory, as it was not the cooling of the gases alone which rendered the subsequent explosions possible, but also the thorough remixture of the gases by diffusion after each explosion. This he illustrated by means of diagrams which represented:

1. A tube filled with an explosive gas mixture which was shown white.

2. The same tube immediately after an explosion had taken place, with a white margin to indicate the unexploded mixture close to the sides, and deep red, toward the middle of the tube, the exploded gases. The white was shown as merging into deep red by degrees, because close up to the sides the surfaces prevented explosion or combustion altogether; nearer the middle partial combustion took place, while only in the middle of the tube the gases found sufficient space for complete combination.

3. The same tube, after the burnt and unburnt gases had mixed by means of diffusion, which was colored light red.

4. The same tube immediately after the second explosion, colored light red at the sides, turning into deep red by degrees toward the middle.

5. The same tube after diffusion has done its work a second time, colored a deeper shade of red.

6. The same tube after the third explosion, colored nearly deep red throughout, but still a lighter shade on the sides.

In Bunsen's mode of determining dissociation at high temperatures, we had only to deal with the obstruction which surfaces offer to combustion, leaving out their dissociating influence at high temperatures, which affected most of Deville's results. For that reason Bunsen arrived at much higher dissociation temperatures than Deville, and his mode of experimenting possessed the advantage that it might lead to a proper settlement of the question of temperatures at which dissociation would set in when taking place in a space unencumbered by surfaces.

By taking a narrow tube of about the same size as Bunsen used for his experiments, and a hollow sphere of the same capacity, in both of which Bunsen's experiment should be repeated, the real dissociation temperature, if no surfaces were present to influence the result, might be approximately calculated.

Bunsen's method of experimenting, according to his view of the matter, should form the foundation of further research to determine the dissociation temperatures of products of combustion. Even if means were found for eliminating the influence of surfaces, no known material at our disposal could withstand the very high temperature to which the vessels or tubes would be subjected if experiments were carried out according to Deville's method.

That the surfaces of highly heated vessels or tubes either produce, or tend to produce, dissociation, had been corroborated lately by two Russian experimentalists, Menschutkin and Kronowalow. These gentlemen found that dissociation of carbonic acid and other gases was much facilitated when the vessels used for the experiments were filled with material offering rough surfaces, such as asbestos or broken glass.

The lecturer's view of the theory of dissociation caused or influenced by surfaces might be given as follows: Increase of temperature producing expansion of gases would reduce the attractive tendency of the atoms toward one another, or, in other words, diminish their chemical affinity. In the same ratio as the temperature was increased, the repelling tendency of the atoms must increase also, until at last decomposition, or what is called dissociation, took place. This being admitted, it would follow that the adhesive or condensing influence of surfaces on the atoms of the gas, which action would increase at high temperatures, would assist this decomposition by increasing the repelling tendency of the atoms.

Victor Meyer, who at first disputed the accuracy of the results obtained by the two Russian physicists, ultimately accepted them, thus confirming the results he had arrived at in practical work with furnaces. Thus the question might be considered nearly settled, the more so as Meyer was himself a great authority in questions of dissociation, having carried out many interesting experiments. Meyer, for instance, proved dissociation by dropping melted platinum into water, and found that oxygen and hydrogen were evolved from the steam produced. There could be no doubt on this point, but the question arose whether heat was the sole agent that brought about the dissociation of steam in this case.

In the first place, the dissociating influence of the highly heated surfaces of platinum on steam had to be taken into consideration, and, secondly, the chemical affinity which platinum had for oxygen, and still more for hydrogen. The same remarks applied to Meyer's experiment of passing steam or carbonic acid through heated platinum tubes, in which case he obtained only traces of dissociation, the temperature being much lower. Other experiments might be mentioned, but none led to a different conception of the question.

There is one other circumstance connected with dissociation, proved by experiment, which, however, required explanation. It was considered as a sure sign that dissociation was going on, when a flame whose temperature was raised became longer; this it was said could only be acounted for by dissociation having commenced. He agreed with this conclusion, but the experiments by which it had been proved had been made, like others referred to, in narrow tubes or passages in which the dissociating action of the heated surfaces must come into play.

It was not alone the heat to which the gases were raised that in these cases caused dissociation, and increased the length of the flame, but also the influence of the heated surfaces in contact with the combustible gases, more especially if these gases contained hydrocarbons. The extension of the flame was also partly due to the obstruction which the surfaces offered to the recombustion of the dissociated gases through want of space. If the same flame were allowed free development in a space unencumbered by surfaces, as in the lecturer's radiation furnace, no such extension of its length would be observed; but, on the contrary, it would get shorter with increase of temperature. This action could be best observed in the regenerative gas-burner exhibited, whose flame became shorter the greater the intensity of the temperature, and therefore of the light, produced.

On the other hand, flame might be extended to almost any length if conducted through narrow passages; this might be seen in regenerative furnaces, which would send the flame to the top of the chimney if the reversing valves were so arranged that the flame, instead of passing through the furnace chamber, was made to burn directly down into the regenerators. No proper combustion could then take place in the brick checkerwork of the regenerative chambers, and the flame would consequently continue to extend until cooled down below a red heat, being ultimately converted into dark smoke; thus in this case the extensive surfaces offered by regenerators would act both ways, by preventing combustion and by assisting dissociation.

It would be understood that regenerative furnaces themselves offered special opportunities for making experiments, most questions, indeed, being best settled by the results obtained in actual work. If dissociation set in, the consequences were seen in want of heat, reduced output, and in destruction of furnace and material. If the causes of dissociation were removed, a rise in temperature, increased output, longer furnace life, and saving of material ensued. Similar results might be obtained with other furnaces, but the beneficial action would not be so great as in the case of the regenerative furnace, because the intensity of heat obtainable in them was much lower.

After describing a new regenerative gas stove he had lately introduced, the lecturer referred to the better distribution of the radiated heat by its use; he found that a room warmed by means of a stove or open fire, such as described, was of a more uniform temperature than when by an ordinary fire or by a gas and coke fire, such as his brother was engaged in introducing into this country shortly before his death.

This, in his opinion, was mainly due to the fact that a source of radiant heat of low intensity, but of large surface, sending out its rays at various angles, heated an object in its vicinity very much more than was the case with a smaller source of radiant heat of greater intensity, whose rays struck the object from one direction only, notwithstanding that both sources radiated the same quantity of heat. This action was illustrated by means of two diagrams exhibited, which represented two rooms, the one heated by a small flame of high intensity, and the other by a large flame of low intensity, both radiating the same quantity of heat. In each room two objects, globes or spheres, were represented, the one close to, and the other at a distance from the source of heat.

The object in the one room, near to the source having the large heating surface, was almost enveloped in rays, while that in the second received rays only in one direction, the former therefore being much more heated than the latter. This difference did not occur when the two globes at a distance from the two sources of heat were compared. The law that the rays of heat diminished in the inverse ratio of the square of the distance was only correct as regards small but intense sources of heat, while the decrease of radiant heat took place in a much higher proportion in the case of large sources of heat of low intensity. This clearly proved that for the purpose of warming rooms by means of radiation, it was important that the heat should be concentrated in an intensely hot focus, as was the case in nature, our earth being warmed in this way by the radiant action of the sun.

* Lecture by Mr. Frederick Siemens at the Royal Institution, Friday, May 7.—*Nature.*

A VEIN of what appears to be first-class burnt umber has been discovered near Newcastle, Pa. It is twelve feet wide, and of unknown depth and extent.

THE USE OF NATURAL GAS AT PITTSBURG.

IT has only been within the past few years that natural gas has been utilized to any extent, in either Pennsylvania or New York. Yet its existence has been known since the early part of the century. As far back as 1821, gas was struck in Fredonia, Chautauqua County, N. Y., and was used to illuminate the village inn when Lafayette passed through the place some three years later. Not a single oil well of the many that have been sunk in Pennsylvania has been entirely devoid of gas, but even this frequent contact with what now seems destined to be the fuel of the future bore no fruit of any importance until within the past two or three years.

It had been used in comparatively small quantities previous to the fall of 1884, but it was not until that time that the fuel gave any indication of the important role it was afterward to fill. At first ignored, then experimented with, natural gas has been finally so widely adopted that to-day, in the single city of Pittsburg, it displaces daily 10,000 tons of coal. The change from the solid to the gaseous fuel has been made so rapidly, and has effected such marked results in both the processes of manufacture and the product, that it is no exaggeration to say that the eyes of the entire industrial world are turned with envious admiration upon the city and neighborhood blessed with so unique and valuable a fuel.

Where the gas comes from, and how long it is going to last—and where it is going to, we might add, now that the scheme of piping it to distant cities is under consideration—are questions which involve so many elements for discussion that we do not propose to take them up at present. The manner of distributing and utilizing the gas, and the industrial revolution its introduction has effected, are more than sufficient to occupy our space. As many of these facts are still involved in mystery to a large majority of our readers, it will, perhaps, be advisable to start at the well itself, and from there follow the gas in its various wanderings until it is finally consumed in the mills and works or in the home.

The regions in which natural gas is found are for the most part coincident with the formations producing petroleum. This, however, is not always the case; and it is worthy of notice that some districts which were but indifferent oil-producers are now famous in gas records. The gas driller, therefore, usually confines himself to the regions known to have produced oil, but the selection of the particular location for a well within these limits appears to be eminently fanciful. The more scientific generally select a spot either on the anticlinal or synclinal axis of the formation, giving preference to the former position. Almost all rock formations have some inclination to the horizon, and the constant change of this inclination produces a series of waves the crests of which are known as anticlines, and the troughs as synclines. Many drillers suppose that the gas seeks the anticlines and the oil the synclines, but others, equally long-headed, discard entirely all theory of this kind, and drill wherever it may be most convenient or where other operators have already demonstrated the existence of gas. It will surprise many of our readers to know that the divining rod, that superstitious relic of the middle ages, is still frequently called upon to relieve the operator of the trouble of a rational decision.

The site having been selected, the ordinary oil-drilling outfit is employed to sink a hole of about six inches in diameter until the gas is reached. In the neighborhood of Pittsburg, this is usually found at a depth of 1,300 to 1,500 feet, in what is known as the Third Oil Sand, a sandstone of the Devonian period. Where the gas comes from originally is an open question. When the driller strikes gas, he is not left in any doubt of the event, for if the well be one of any strength, the gas manifests itself by sending the drill and its attachments into the air, often to a height of a hundred feet or more.

The most prolific wells are appropriately called "roarers." During the progress of the drilling, the well is lined with iron piping. Occasionally this is also blown out, but as a rule the gas satisfies itself with ejecting the drill. When the first rush of gas has thrown everything movable out of its way, the workmen can approach, and chain the giant to his work. The plant at the well is much simpler than one would suppose. An elbow joint connects the projecting end of the well piping with a pipe leading to a strong sheet iron tank. This collects the salt water brought up with the gas. Ordinarily, about half a barrel accumulates in twenty-four hours. A safety valve, a pressure indicator, and a blow-off complete the outfit. When the pressure exceeds a prescribed limit, the valve opens, and the gas escapes into the blow-off. This is usually 30 feet high or more, and the gas issuing from the top is either ignited or permitted to escape into the atmosphere. The pipe line leading from the tank to the city is of course placed underground. Beyond a little wooden house, the blow-off, and a derrick, the gas farms differ little in appearance from those producing less valuable crops.

The pressure of the gas at the wells varies considerably. It is generally between 100 and 325 pounds. As much as 750 pounds per square inch has been measured, and in many cases the actual pressure is even greater than this, but, as a rule, it is not permitted to much exceed 20 atmospheres in any receiver or pipe. The maximum pressure in the lines of the Philadelphia Company is 340 pounds. The supply of Pittsburg is largely in the hands of this organization, and drawn from its wells at Tarentum and Murraysville. A number of other companies are also in the field, but the chief business of the city is still controlled by the Philadelphia. The question of pipage is one of immense importance, and, with increased knowledge of the best conditions for securing an even flow of gas, becomes even more prominent, for the lines are being rapidly extended in length, and it is asserted by many practical gas men that they will some day reach the seaboard.

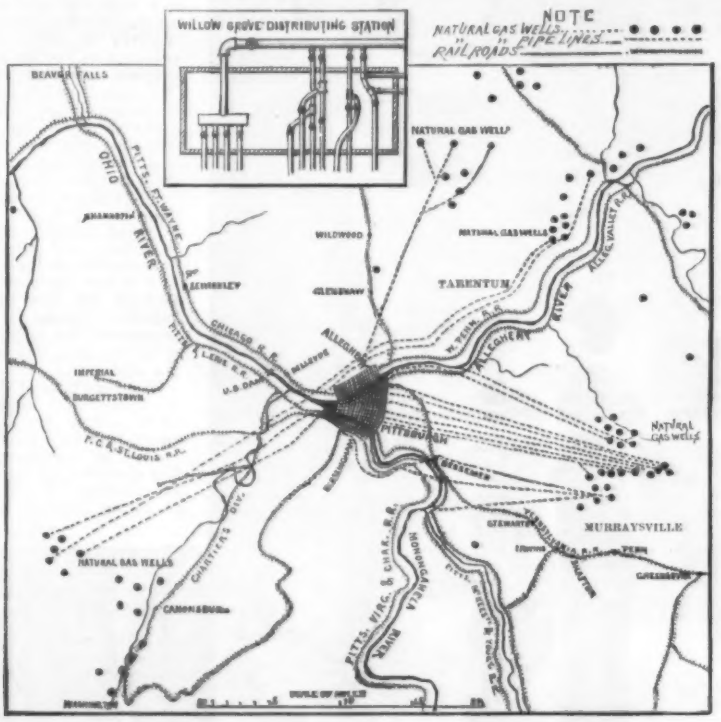
The pipe lines of the Philadelphia Company vary in diameter from 4 to 10 inches. The Chartiers Company, however, have one line of 16 inches in diameter. In the city, the distributing mains are from 4 to 24 inches. The general tendency is to an increase of diameter, in

THE USE OF NATURAL GAS AT PITTSBURG.

order to lessen the friction and enable the supply to meet any unexpected demand without interfering with the usual flow. The average diameter of the city mains may be stated at 16 inches. The distributing pipes vary from 4 to 10 inches. The pipe lines have to be laid with the greatest care, to withstand these high pressures and avoid leakage. They cost from $2,000 per mile for pipes of 4 to 8 inches up to $30,000 for 24 inches. The Philadelphia Company alone has about 375 miles of pipes 4 inches in diameter and over.

Every day, line walkers go over the entire line, and submit reports of its condition to the central office. Every leak, no matter how small, is included in the report. In addition to this daily inspection, a man is sent by the company to every fire, and it is his duty to turn off the gas from the burning building and from any that may be in immediate danger. The question of pressure throughout the lines is one of vital importance, and its regulation demands constant attention. For this purpose, valve houses, or stations, to the number of 22, have been established at various points on the line as well as in the city, and at Tarentum, Murraysville, and Dick Farm. At each of these stations the pressure is registered every hour. The company has four telephone lines of its own, of a total length of about 80 miles, and each station is connected with the central station on Penn Avenue. In this way the supply all over the city is closely watched.

Should it become deficient in any district—which would be indicated by a marked decrease in the pressure—it is but a moment's work to call up the central station, and have more gas turned into the needy district. An early disadvantage in using natural gas was its constant liability to failure, but this system of telephonically connected stations has done away with this, and created a confidence in the reliability of the supply. The arrangement of the pipage and gates at these stations is shown in our diagram of the Willow



Grove Station. Coming, as most of the gas does, a distance of twenty miles or so, its pressure is much reduced during the journey by friction against the sides of the pipes. It is contrary to law to maintain a pressure of more than 15 pounds within the city limits. Consequently, blow-offs are established at various points; and whenever the pressure exceeds 10 pounds, the safety valve opens, and the gas escapes.

This leaves a margin of five pounds, but in some of the older and smaller pipes the pressure does sometimes exceed 15 pounds, as a heavier force is needed to overcome the increased friction.

During the day, when the mills are running at full force, the pressure in the city mains is from 2 to 5 pounds; but at night, and more particularly on Sundays, the pressure becomes greater, and large volumes of gas escape at the top of the blow-offs. The one on the Allegheny River at the foot of 10th St., shown in our illustration, Fig. 1, as it appears on Sunday evening, is 40 feet high, and perforated at its upper end for a distance of 3 feet. The immense flame, 40 to 60 feet long, as it is blown about by the wind, has the appearance of a giant torch. To a stranger there are few sights more striking than that presented when he looks down from one of the surrounding hills, and sees the city at night illuminated by these lurid flames. The custom of keeping these torches lighted is not maintained, however, entirely for scenic effect, but in many cases is intended to avoid the noise of the escaping gas. At such a height, the gas would do no damage, if permitted simply to escape into the air. Having a specific gravity of only about half that of air, it is dispersed immediately into the upper regions of the atmosphere.

There are now few mills or furnaces in Pittsburg or the vicinity that are not using gas exclusively. At the Edgar Thomson Steel Works, at Braddocks, the gas is used in all departments where coal was formerly employed. The furnaces used for reheating the steel billets, that are afterward rolled into rails, are shown in Fig. 2, and will give some idea of the scale upon which this immense establishment has been built, and the importance which such a change of fuel means. If one has visited Pittsburg in the days of coal and smoke, he has only to go on the streets and notice the comparatively clear atmosphere and the clean faces to realize what a blessing natural gas has been, aside from its economic value. In the boiler room the change is no less marked. The bricks are neatly whitewashed, the ironwork painted, and the engineer sits in one corner of what might be a parlor as far as neatness goes, quietly watching a water gauge and indicators. The best arrangement for burning the gas under the boiler is that practiced by the Electric Light Company at their central station in Virgin Alley, shown in Fig. 3. The gas passes into a 4 inch drum extending in front of the boilers, and thence by a 1¼ inch pipe into T-burners in the front of the firebox. These are simply perforated pipe, 2 inches in diameter.

The air for combustion is first heated before mixing with the gas. Sheet iron is placed upon the grate bars to within about 4 inches of the rear, and 2 inch tiles are placed between this and the boiler, leaving sufficient space in front for the flame to play over them. The air enters beneath, and passing along the under side of the tiles is heated before coming in contact with the gas. It is very important at such an establishment to be able to burn coal at very short notice, should any accident happen to the gas supply. As at present arranged, the entire change can be made and a coal fire started within eight minutes. The gas is burned under the boilers at a pressure of from three-fourths to one pound. As the pressure in the mains is considerably in excess of this, it must be reduced by an automatic regulator. In dwelling houses the gas is seldom burned under more than 2 to 6 ounces.

The regulator, Fig 6, is a very important piece of apparatus, as it must be used in every mill or house where natural gas is burned, as well as in regulating the pressure where the mains enter the city limits. It is not understood, even by the majority of the people who use it; but if the reader will follow closely our description, he will at least be able to get a general idea of its action. The city inlet terminates in a small cast iron chamber, having two valves on opposite sides. These valves are on the same piston rod, and consequently, when this is moved, one opens toward the interior and the other toward the exterior of the chamber.

A second chamber is divided into two parts by a rubber diaphragm, the upper portion being in communication with the atmosphere, and the lower with a space surrounding the small chamber first mentioned. The diaphragm is weighted above, and below acts upon an elbow lever connected with the valve rod. It will be understood that the lever is in the chamber under the diaphragm, and that the valve rod operates in the inclosed space communicating with this chamber. Bearing this disposition of the apparatus in mind, when the gas enters the small chamber it opens the valves and passes through into the surrounding space and into the chamber under the diaphragm. As the house inlet opens from this inclosed space, the gas has now free access to the service pipes. But the gas raises the diaphragm, and through the lever closes the valves, shutting off the supply. As the gas is consumed the diaphragm sinks under its weights, and more gas is admitted. By altering the weights, the regulator may be set to deliver gas at any desired pressure less than that of the initial. Should the supply of gas be cut off, the regulator automatically locks itself, and will deliver no gas until locked by hand. This prevents the escape of gas, should it be put out by a temporary failure of the supply and then turned on again. As it is so largely composed of marsh gas, it forms, when mixed with air, an explosive compound similar to the deadly fire damp of the coal mines. Consequently, fire must be applied to the orifice before the gas is turned on, or else there will be an explosion. To avoid such a possibility, a small jet of gas is often allowed to burn all the time, in order to light the larger burner as soon as it is turned on. The new fuel is becoming extremely popular for domestic use. In grates, a flat perforated box, as shown in our engraving, Fig. 5, is commonly placed in the bottom, and covered with fragments of fire clay. In cook stoves, Fig. 4, T-burners are used, generally in pairs, though usually only one is lighted unless a large amount of hot water is wanted in the boilers. In round stoves it is common to use simply the Bunsen burner without the box attachment. The price of gas is usually a matter of contract, based upon former coal bills or upon the mill product. In Allegheny City, however, it is sold at ten cents per thousand feet, and at this rate may be a little more expensive than coal, but is used nevertheless on account of its great convenience. There have been a number of distressing accidents attending the use of the gas, but the total fatality, it is well to remember, is much less than that of a single mine disaster such as that at Nanticoke.

THE MANUFACTURE OF WINDOW GLASS WITH NATURAL GAS.

THERE is probably no industry among the many that have been benefited by the utilization of natural gas in which the results have been so marked as in the manufacture of glass. For a number of years past, American glass has been undoubtedly inferior to the product of European factories, and has consequently occupied but a secondary position in the estimation of American builders and architects. The foreign manufacturers, and particularly those of France and Belgium, have hitherto manifested a superior dexterity in the handling of their materials. They seem to have held the secret of either neutralizing the effect of impurities in their fuel, or of burning it in such a manner as to get the minimum disadvantage from their presence. This has been due partly to greater experience in the industry and partly to a better construction of furnaces. In some of the more perfect plants, crude fuel has been abandoned and manufactured gas used instead, thus giving them in advance the advantages of natural gas, with the important exception, however, of its cheapness and almost total freedom from sulphur. These circumstances made imported glass synonymous with best quality.

That these conditions have now so far changed that our own glassmakers can compete with the best foreign producers, and can even honestly claim certain points of superiority for the home product, is a subject for hearty congratulation. The improvement has been effected, in a measure, by the more complete mechanical appliances now at our command, but the most potent influence must be ascribed to the use of natural gas. In the manufacture of window glass, the results have been particularly gratifying, many important buildings being now fitted with American glass which but a few years ago would have demanded the imported. The metamorphosis of the crude material into a clear and brilliant pane of glass involves so many interesting points that we have illustrated the process, choosing the works of Messrs. S. McKee & Co., at Pittsburg, as a typical establishment.

The manufacture of sheet glass depends for its success upon the closest attention to details, and its history is therefore one of delicate manipulations. It is a very easy matter simply to make glass, for it is nothing more than a double silicate of soda or potash and an alkaline earth. The iron-master gets rid of the silica in his ores by making it into a fusible silicate of lime—an opaque glass. The assayer frees his metal from the accompanying gangue by adding suitable fluxes until all the earthy matter is gathered into a fusible slag, and floats above the metal button as a molten glass. And even nature, when her interior caldron bubbles over in a volcano, shows that she, too, is a giant glassmaker. But to make good glass, clear, transparent, colorless, to simulate the purest water of a mountain stream, this requires skill and patience.

These two qualities are demanded in all stages of the operation. The first step is the manufacture of the crucible pots, and in this the glassmaker has a good opportunity to display these qualifications. The pots are made up of a mixture of about 2 parts raw fire clay, 2 parts burned clay, and 1 part ground pot shells, and require the greatest amount of care. The mixture is ground and thoroughly worked in a long trough, where it is turned once a day for a period of about four weeks. The workman kneads the plastic mass with his bare feet to make it tough and free from air. If the treatment is imperfect or careless, the entire subsequent work of the crucible will be unsatisfactory. The pots are formed entirely by hand, and in a room the temperature and humidity of which are kept as nearly constant as possible. They are all of one size, 33½ in. deep and 42½ in. across the top. The thickness varies from 3½ inches at the base to 3 inches on top, while the bottom of the pot is about 4 inches. The bottom having been first formed, the sides are gradually built up from day to day, the entire process requiring about six weeks. The capacity of the pots is from fourteen to sixteen hundred pounds of molten glass. When quite dry, they are placed in small heating furnaces, where the temperature is gradually raised to that of the melting furnace, and when this point is reached they are quickly transferred, and are then ready to receive the raw materials.

At the McKee works there are three melting furnaces, having a total capacity of 26 pots. These stand two abreast, one of the furnaces having 10 pots and the other two 8 each. Round openings in each side of the furnace permit free access to each pot. The fuel, as everywhere else throughout the works, is natural gas. This is admitted at each end of the furnace, and is mixed with air which has been heated by passing through chambers in the firebrick arch. A well is built under each furnace to collect the molten glass, should a pot break, and thus prevent loss of material or stoppage of the furnaces. The raw material, or "batch," introduced into the pot consists of sand, 100 parts; lime, 30 parts; alkali, 40 parts; and a small, but varying, amount of pulverized charcoal. Some manufacturers make their alkali all sulphate of soda, while others employ a mixture of sulphate and carbonate, in the proportions shown by their experience to be the best.

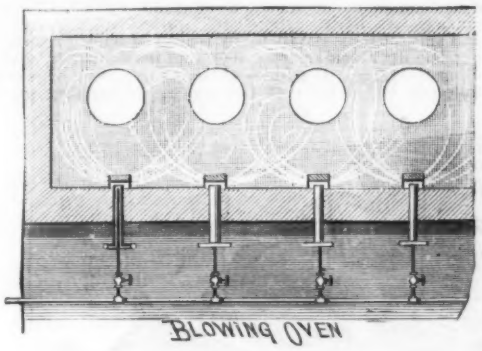
These are thoroughly ground and mixed together. One-third of the full charge is placed in the pots, and after an interval of four hours a similar amount is added. With the last charge, introduced still four hours later, about two pounds of arsenious acid are added. This acts as a bleaching agent, and by converting the iron present into a higher oxide, removes the color to a large extent. At some establishments peroxide of manganese is used for this purpose, but a slight excess will give a pinkish color, and it also has the further disadvantage of making the transparency of the glass less durable. When the contents of the pots are quite liquid, and have settled down to a constant level, enough broken glass is added to fill the pots completely. This is known as the "capping." The entire melting occupies about 16 hours. During the latter part of this time, the heat is somewhat reduced, in

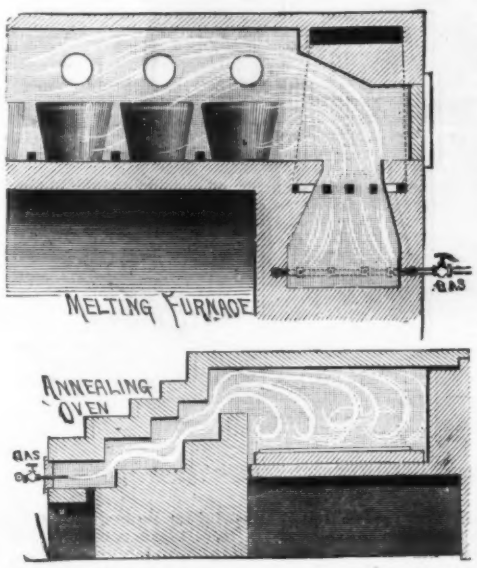
order to make the glass less liquid, and prepare it for gathering.

When the fusing period is completed, the surface of the molten "metal" must be freed from all impurities by skimming. For this purpose a fire-clay ring, introduced when the pot is first put into the furnace, floats upon the surface of the bath, and the gatherer, by removing all the scum from the interior of this ring, always has a clear surface from which to draw.

The gathering is done with a wrought iron pipe, about five feet long, the end of which is decidedly flared. Toward the mouthpiece, the pipe is surrounded with a wooden handle. The first dip brings out but a small lump of glass. By careful turning of the pipe, this is gotten into symmetrical, oval form. Three times the gatherer dips his pipe into the molten bath, each time getting a little more glass, until at the end he has a mass weighing from 15 to 20 pounds. If, however, window glass of double thickness is to be made, the metal must be gathered four or five times, and the resulting ball will weigh from 30 to 40 pounds.

It is at the final dip that the gatherer's greatest skill is called into requisition. The mass of red hot plastic glass must be gotten into symmetrical shape, and must be thoroughly homogeneous before it can be handed over to the blower. The pipe is therefore placed on a convenient fulcrum, the end carrying the ball of glass being in the furnace, and by depressing the handle and revolving the pipe the last glass added is made to completely overlap the former ball. The entire mass is brought to a uniform temperature but little short of liquidity, and by a further revolution of the pipe the fold of glass formed by these manipulations is turned



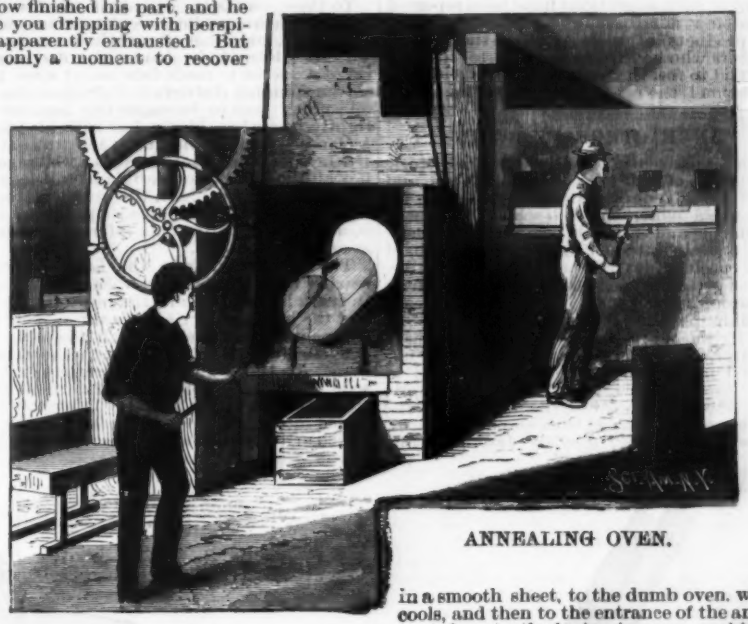


into a spiral and worked to the end of the mass. The ball of glass, red hot, and, if properly gathered, without flaw or blemish, is now taken to a wooden mould, placed at the right of the blowing furnace, and by dexterous turnings is formed into a pear-shaped ball. The wood is kept from burning by being continually moistened with water, which, in contact with the red hot glass, assumes a spheroidal condition, and looks like so many globules of mercury. The gatherer's duty is now ended, and he hands pipe and glass over to the blower.

Formerly, the melting and blowing furnaces were combined in one, but it has been found more economical to have them separate. The blowing furnace has the same side openings as the melting furnace, and simply provides an intensely hot chamber for controlling the temperature of the glass while being blown. The first act of the blower is to grasp the pipe, and with the ball of glass still resting in the mould, blow through the mouthpiece until a large bubble of air is formed in the mass of glass. Then, with alternate blowing and manipulating, he increases the bubble until the mass takes the shape of a large carboy, such as one uses for transporting acids.

The blower now transfers his operations to the platform in front of the blowing furnace, where long openings permit him to swing his pipe and globe of glass in a pit beneath. Blowing and swinging and reheating, he extends the bubble at the pipe's end, until, in place of the ungainly carboy, with its disproportionately thick bottom, he has a beautifully symmetrical figure, the shape of an enormous test tube. But during these operations it happens from time to time that the glass flows a little too freely, and the sides of the tube are in danger of becoming too thin. So the blower must occasionally throw his tube into the air and let the glass settle back upon itself. As the tube by this time is about 5 ft. long and from 15 to 18 inches in diameter, one can readily fancy that this apparently playful toss requires great skill and a large amount of muscle.

When the tube is formed to the satisfaction of the blower, he permits it to become comparatively cool, thrusts the end into the furnace, blows into his pipe, and quickly covers the opening with his hand. A slight report is speedily heard. The confined air, expanding with the heat, has blown a small hole in the end of the tube. Resting his pipe on a suitable support, he gradually turns it around, while the hole grows larger and larger until he no longer has a test tube, but a complete cylinder. Quickly he withdraws his pipe from the furnace, and allows the cylinder to depend into the pit below until the plastic edge passes to cherry red, and it can be taken away without danger of getting out of shape. The blower has now finished his part, and he stands before you dripping with perspiration and apparently exhausted. But it takes him only a moment to recover



LAYING IN.

his breath. Already another pipe is in his hand, and he is repeating his heavy labor.

A string of red hot glass adroitly drawn around the cylinder end causes an even crack to separate the neck and attached blowpipe from the cylinder proper. Then a hot iron is passed along the interior surface from end to end, and makes a longitudinal crack. As a cylinder, the glass looks as if it were pretty well ruined, with a crack running its entire length, but the process is only another step in its transformation into a window pane.

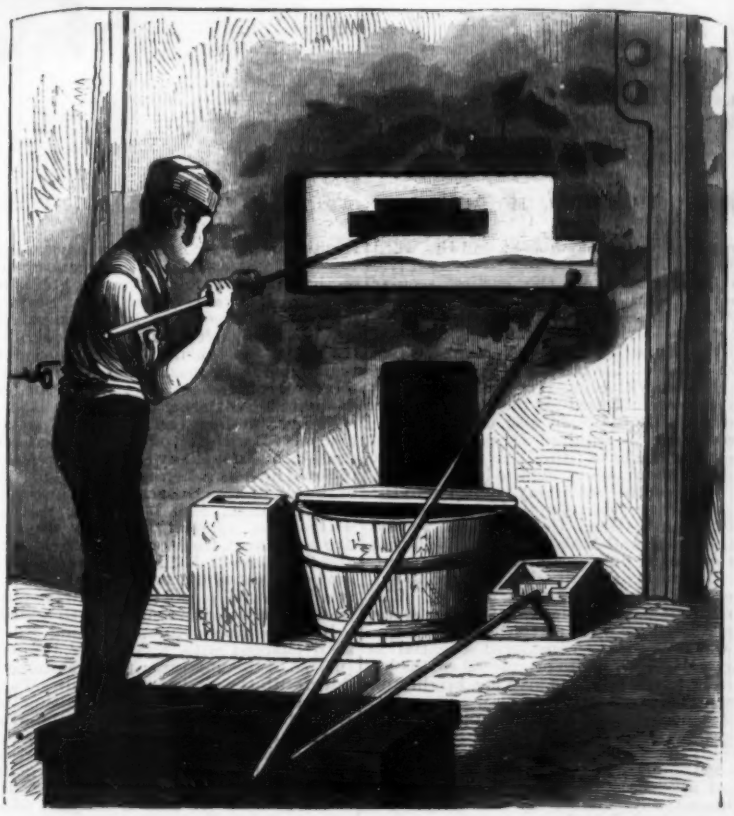
The cylinder is now ready for the laying-in furnace. This is in a separate building, and of late years has been made one of the most complete parts of the entire plant. The hearth of the furnace is circular, and is divided into several sectors, separated from each other by fire-clay bridges. As the hearth revolves, these sections pass through a corresponding number of compartments, in which the temperature may be varied at pleasure. The first compartment is only moderately heated, and is known as the laying-in oven. In this the cylinder becomes gradually warmed. A partial revolution of the hearth then carries it to the next compartment, the laying-out oven, where the heat is sufficient to make the glass plastic. On the floor of each section of the hearth a large flat stone, made of fire-clay and prepared with the greatest care, so as to be perfectly smooth, is adapted to receive the cylinder. While in the laying-in oven, the cylinder is supported by two brackets at the side of the stone; but as soon as it reaches the laying-out oven, it is removed to the stone, and, the crack being uppermost, is allowed to untold until it lies open like a sheet of rumpled paper. It is then carried by the revolution of the hearth to the flattening oven, where a workman, as shown, irons out the plastic sheet until it lies perfectly smooth and flat. Further revolutions of the hearth carry the glass, now

ANNEALING OVEN.

in a smooth sheet, to the dumb oven, where it slowly cools, and then to the entrance of the annealing oven, next door to the laying-in oven, making the circuit finally complete.

When the comparatively cool sheet of glass reaches this stage of its journey, it is picked up with a large two-pronged fork and placed upon a rod or bar projecting from the annealing oven. These rods are found an immense improvement over the car formerly used. They handle each sheet separately, and with the receipt of each fresh sheet they move the entire contents of the annealing oven toward the outer end, discharging a finished sheet at that end. The glass remains in the oven from 30 to 40 minutes. When discharged, the sheets are cut into proper sizes and stored in suitable frames.

The process is completed. The surface of the glass, just as it comes from the annealing furnace, is remarkably brilliant and as beautifully clean as if it had been washed in hot water and dried with linen. In all stages of the process the advantages of natural gas become each day more evident. The more intense heat



THE MANUFACTURE OF WINDOW GLASS WITH NATURAL GAS.—FLATTENING.

of the new fuel gives a better fusion, while the contamination of the "metal," from particles of coal and cinder, is entirely avoided. It is, however, in the blowing furnace and flattening oven that the most marked advantages are obtained. With coal, the sheets of glass formerly came from the ovens coated with smoke, and, what was infinitely worse, with a white deposit of

sulphur. As these impurities had been gathered while the glass was in a semi-plastic condition, no subsequent washing or acid bath could entirely restore the brilliant surface.

A comparison between new and old glass will make these differences very plain. But perhaps one can best appreciate the influence of gas upon the industry by glancing at the history of those establishments which are not so fortunate as to possess it. So radical, indeed, has been the change wrought by the new fuel, that several important glassworks in other parts of the country have admitted that the competition is too unequal, and have either suspended business or transferred themselves to the shadow of the nearest gas derrick. A number of such migrations have been reported during the past few months. It is a gratification to examine the products of such firms as the Messrs. McKee and others who have done so much to advance this industry, and to feel that our architects can now honestly recommend the use of American glass.

THE MANUFACTURE OF SOAP.

THE first manufacturer of soap lived in prehistoric times, before the age of bronze or of worked stone, and possibly before the advent of man upon the earth, for the first sheep was a maker of potash soap. The experiments of Maumene and Rogelet prove that a fleece weighing 9 lb. contains about 7 oz. of pure potash, of which they consider nearly 6 oz. to be recoverable, although it is at present often wasted. This potash on the sheep's exterior, mixing with a portion of the greasy matter of the skin, produces a certain amount of soap; consequently, by washing a sheep with a limited quantity of pure water, it is possible to get up a lather. Thus the agricultural laborer of the future, advanced in scientific education, may in washing the faces of his proverbially numerous children utilize the pet lamb of the family as a large sponge charged with soap.

The Hebrew word *borith*, used by Jeremiah, and translated "sope," refers to potash lye; and the word *nether*, translated "fuller's sope," refers to mineral lye, or soda. Pliny and Galen are the earliest secular writers who speak of soap. Pliny says that it was made by the Germans and the Gauls, that it was sometimes hard and sometimes soft, and that it was made of goat's fat and the ashes of the beech tree. Galen says that it was made of the tallows of the ox, sheep, and goat, strengthened with lime. In those early times it appears that soap was not used for washing purposes, but to dye and beautify the hair, also as a medicine; sometimes it was made as required for use, ashes and oil being rubbed over the head; thus it is possible that the ancient sayings about anointing the head with oil, and casting ashes upon the head, may, contrary to the general impression, have had reference to a process of beatification by sponification. Geber, in the second century, speaks of soap, and Arab writers mention that it was used for cleansing purposes, also as an ointment. Strabo states that in his day alkaline water was employed by the Armenians for washing clothes. The ancients also used saponaceous plants as well as seeds, bran, and fuller's earth for washing purposes.

Much water was not always considered essential in these cleansing operations, white or colored earths being often rubbed into the fabric to give it a bright uniform appearance, just as our soldiers now use pipe clay, and as glovers sometimes improve the appearance of leather.

In more modern times France was for a long time in the van in the manufacture of soap, that of Marseilles being celebrated all over Europe, and holding a front rank to the present day. The soap manufacturer of England was once retarded by heavy taxation, and by the presence of excise officers in the factories, so that the makers, knowing that any improvement they might make was liable possibly to be communicated to their competitors by persons over whom they had no control, had small temptation to try novel processes. The soap duty was not repealed until 1853; in the beginning of that year the duty on soft soap was a penny a pound, and upon hard soap three halfpence. As there was then no duty upon soap in Ireland, smuggling of soap between England and Ireland was common.

Soap is made by boiling tallows or oils with one or other of the fixed alkalies, potash and soda; potash produces soft soaps and soda hard soaps. Ammonia is slow in acting upon oils and fats; the union can be effected with time and difficulty, but the products have no special application, and are not manufactured commercially.

The practical applications of the brilliant series of discoveries made by Chevreul early in the present century, on the chemistry of the fatty acids are now carried on, on a large scale, in the various works of Messrs. J. C. & J. Field, who have works for the making of soap for manufacturers connected with various trades, at Bermondsey Newroad, London.

To these works the oleic acid freed in the manufacture of stearine candles is sent to be saponified; cottonseed, olive, and other oils are there also made into soap. The great thing to be done with cottonseed oil is to get rid of it; some is made into soap; some goes from the cotton spinning districts to Italy, to come back as olive oil; much goes to lubricate the familiar sardine, less tightly packed in his tin box with his friends than an Icelandic family by night in their hut—at least so says Dr. Leitner, who asserts that in a well regulated sardine box all the inhabitants can lie at full length, but in an Icelandic hut by night, the dwellers, though equally tightly packed, are doubled up. Good cottonseed oil is, at any rate, better than inferior qualities of olive oil as an article of food.

The oleic acid from the Lambeth candle works reaches the Bermondsey works in casks; the bung of the cask is removed, and the pipe of a pump is inserted and the liquid pumped into an iron spout, down which it runs into the vessel in which it is to be boiled, which is made of iron, but called by the workmen "the copper." At the same time a warm solution of caustic soda is pumped from the floor below into the same spout; the oil and alkali mix in the spout, then fall well mixed into the copper. The alkali used is caustic soda, which arrives at the works in a solid state in iron drums, having been poured therein at a great heat at the alkali works. Caustic solid soda exerts no chemical action upon bright iron. Each drum contains a solid cylindrical lump of soda weighing 5 cwt. Several of these huge lumps are placed in a large iron vat, water is added, and the whole left for about forty-eight hours, for after the water has taken up a certain amount of soda the remainder of the mass is but slowly soluble. When the solution commences over night, the heat which is generated by the act of solution is at its maximum next day; in fact, the warmth of soda lye when it is first mixed with the oil in the spout is due to the hydration, and not to any external application of heat. Additional heat is generated by the more complete union of the alkali with the acid oil in the copper, a maximum of over 200 deg. Fah. being thus reached, if necessary, without the application of any fire at all. There are five coppers at the works, each holding five tons of lye and five tons of oil. The ten tons of liquid in the coppers are boiled for about twenty-four hours, then the mixture is allowed to cool; the spent lye is next run off, and fresh caustic of different strength added.

In the boiling a scum, consisting chiefly of imperfect soap charged with minute air bubbles, forms at the surface of the mixture; this is skimmed off and boiled down with the next make of soap. The treating of oils with alkaline lyes is termed "salting," and as oils vary the salting is performed again and again until an approximately neutral stage is reached; when neutral, the soap is tasteless when the tongue is applied to it. A small surplus of alkali, such as is usually present, gives soap the well known strong alkaline taste. The strength of the lye used is one part of soda to six parts of water in the first boiling; in subsequent boilings the strength of the lye is considerably greater. One part of oleic acid soap usually contains sixty-eight parts oil, seven parts soda, and twenty-five parts water.

Olive oil soap is at first green; afterward it turns yellow, more especially where exposed to the air and in parts adjacent thereto; this is probably due to the evaporation of water. The cost of the caustic soda used is about £10 a ton; its chief impurities are sulphate and carbonate of soda, varying from 8 to 12 per cent.

When the saponification is complete, the soap is disseminated in the spent lye as a mass of globules, which have to be boiled briskly until they coalesce. Strong lye is then added, which "throws out" the soap insoluble in that medium. The copper is then left to cool down, after which the soap is ladled into large, built up, rectangular wooden or iron moulds, within which the soap solidifies, but is stirred occasionally with a kind of a wooden crutch, to make it homogeneous throughout, hence the mixing of soap is technically called "crutching," and varieties of apparatus for mixing it go by the name of "crutching machines." When the soap has hardened in the mould, the sides thereof are unscrewed and removed from time to time, from the top downward, leaving the block of solid soap exposed and ready to be cut into bars by wires.

The soaps made at Messrs. Field's Bermondsey works have long been known to dyers and cleaners under the name of "pure oil soap." While all other soaps are mixtures of stearates, palmitates, oleates, and resinates of soda in various proportions, the soap above described is almost pure oleate of soda, the interest of the makers, in view of the far higher price of the solid stearic acid, leading them to extract it as thoroughly as possible from the cheaper oleic acid. This is accomplished by freezing and cold pressing, processes which inventors of late years have carried to great perfection. The saponified oil produced from the lime process described in our article on candle-making is finer than the oil yielded by distillation, inasmuch as the latter process tends to break up the oxy-acids into unsaponifiable hydrocarbons. The presence of the latter in an oil soap becomes apparent on dissolving it in water. If pure, the solution is perfectly transparent and bright; if hydrocarbons be present, the liquid is opalescent and murky. As hydrocarbons are quite insoluble, dyers and spinners dislike them by reason of their permeating the fiber under treatment and permanently dimming the same. It will be evident to any one who has followed the details of the process of making pure oleic acid soap, that it must be far more alkaline than such soaps as are "cut" with salt liquor, which washes out the excess of soda. This preponderance of alkali is no detriment in the eyes of the consumers, who find it serviceable in cleaning the somewhat intractable materials of their trade; indeed, some will not look at a soap which is not incrusted with the carbonated alkali; it is a guarantee to them that no unsaponified fat is present, for such fat would be bad for their purposes. For delicate colors, especially of aniline origin, pure oil soap is unsuited, as the free alkali instantly takes the acid from the brilliant salt, leaving the colorless base. Messrs. Field, however, are engaged in experiments which promise shortly to give the world a chemically neutral soap.

The toilet soaps of Messrs. Field, the manufacture of which we are now about to describe, are not made at Bermondsey, having nothing in common with the class of soap there produced. The machinery is fitted up in a part of the Ozokerit Works, at Battersea. The chief of the many products of the Battersea Soapworks is the so-called "Samphire Soap," but samphire enters as little into the composition of its godchild as honey or Windsor into their respective synonyms. The name has been selected as that of the best known sea plant, and typifying sea air and water, the qualities of which are condensed in the soap of that ilk. The body of this soap consists of olive oil which has been saponified with potash obtained from burnt seaside plants, and afterward "cut" with salt, thus forming a soda soap, with sufficient potash to impart softness and mildness to the otherwise hard and insoluble soda compound. This is melted in a special steam pan, with palm oil and other refined soaps. When thoroughly liquid, the mass is subjected to a process which neutralizes the free alkali present in all crude soaps; this result is further assured by the addition of several vegetable acids, such as thymic and salicylic, and a proportion of iodized and brominated eucalyptol. About 20 per cent. pure glycerine is finally worked in, and the whole stirred for several hours at the highest possible temperature. The soap is then allowed to cool a couple of days in iron frames holding about 3 cwt. each. When cold the block is cut into slabs, and then into bars,

FIG. 1.—SOAP SHREDDING MACHINE.

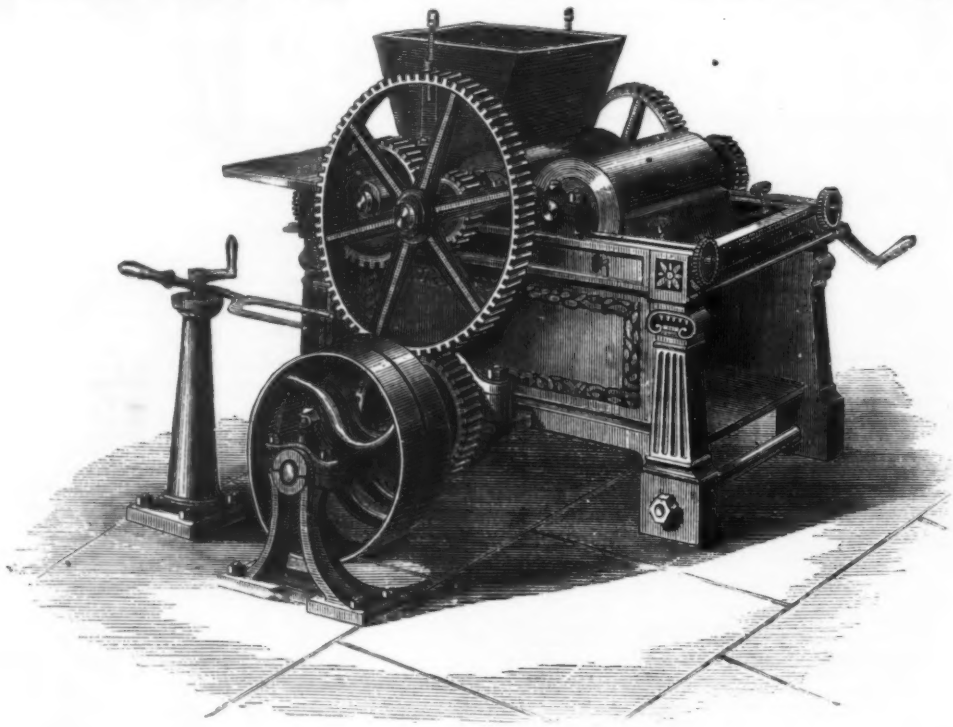


FIG. 2.—SOAP MILLING MACHINE.

which in their turn are finally shredded in a machine to be hereinafter described.

These shreds are first dried on wire netting in a hot chamber at 200 deg. Fah. for twenty-four hours, during which time they lose 25 per cent. of their initial moisture, retaining about 2 or 3 per cent. held by the glycerine. The chips are now passed through the mill —*v. infra*—four or five times, till perfectly homogeneous, and thence removed, now as long strips greatly resembling seaweed, to the plotter, or screw-press, whence the soap issues as a long bar, exceedingly hard and of a deep green tint. This is cut, while still warm from the pressure of the screw, into cakes suitable for stamping, which operation is not performed before they are a week old, and capable of rendering the engraver's work in sharp completeness of outline. Thus the completion of the process in which the crude oil attains to fullness of completion as salable soap occupies nearly a fortnight.

The above description applies to all soaps treated in this manner, that is to say, milled soaps, with the ex ception of the base soap, and the coloring and scenting. Samphire soap has no artificial color and scent, but the public eye and nose demand these adjuncts, and the populace sometimes obtain them at the expense of their skins. The color, generally a solution of some aniline or anthracene compound, and the scent, which may perhaps be cassia, citronelle, cloves, or storax, are sprinkled on the chips while in the hopper of the mill, the action of which is quite sufficient to thoroughly incorporate them with the soap.

The milling and plotting portions of the above process were perfectly and thoroughly shown by Messrs. Cleaver, at the Health Exhibition at South Kensington, in 1884; and some of our readers perhaps remember the ingenious stamping appliance, with its mechanical fingers for removing the embossed cake from the mould. It would not be remunerative, however, to make the common soaps, such as are sold retail at 6d. a pound, by this method. A certain class also, known as Windsors, lose some of their characteristic qualities when milled; for their manufacture the crutching machine is employed, with the addition of pearlash or carbonate of potash. Thus, at Messrs. Field's, the well-known United Service soap—a typical brown Windsor—is made as follows: Scraps and cuttings from previous boils, and from all the finer toilet soaps turned out at the factory, are melted down with a proportion of palm oil or skin soap and Cook's primrose. The mixture is thoroughly crutched, framed, cooled, stripped, shredded, and again melted. By this double melting the soap is very thoroughly united or welded, and acquires emollient qualities. A strong solution of pearlash being now stirred in, in about the proportion of one pound to each hundredweight of soap, the paste, which heretofore was dark and transparent, becomes light yellow and opaque, much resembling butter in appearance and consistency. The philosophy of this action of the pearlash is at present unknown. Of the marked nature of the change there is no doubt; possibly an interchange between the potash and soda takes place, or double oleates of potash and soda are formed. Who knows? At any rate, it is not possible to make a good remelted toilet soap in this manner without pearlash, although that compound is undesirable because of its tendency to throw out or incrust the soap, thereby spoiling both the appearance and the sale. There is no doubt, also, that the extra alkali must act injuriously on delicate skins, to a considerably less extent, though, than is sometimes asserted. After the pearlash has done its work, the scent is added, which, in the case of the United Service soap and brown Windsors generally, consists of vegetable gums and balsams, with civet, ambergris, and so on, according to the taste and opulence of the manufacturer. The mass is then framed and caked as before.

The soap-making machines used at Battersea were constructed by Messrs. Morane & Co., Rue du Banquier, Paris. The soap-cutter, or slicer, represented by Fig. 1, makes about 100 revolutions per minute, and is fed with bars of soap by means of a wooden guide placed at an angle to the cutter. The disk on which the cutters are mounted is slightly conical, and about 12 in. in diameter across the face. The cutters are usually four in number, and are fixed radially from the center of the disk, performing their cutting operations in much the same fashion as an ordinary spokeshave. The slices cut are thin and wet; care has to be taken not to shave them too finely, or they would so cling together in the wooden receptacle below the slicer as to form an almost homogeneous mass, and thus defeat the object of effecting division. Next the chips are spread upon cloths, and placed upon the wire netting in the drying cupboard until they are dry and brittle.

Fig. 2 represents the granite rolling mill. It consists of three granite rollers, each about 2 ft. long and 12 in. diameter, supported on a strong iron framework; the rollers, as already stated, rotate at different speeds relatively to one another. The spur gearing by which this is effected is so arranged as to give the first roller about 20, the second 32, and the third 48 revolutions per minute. The driving of the rollers themselves, added to the milling they have to perform, is heavy work, and absorbs much power. The rollers revolve in adjustable bearings to regulate the thickness of the milling; as a rule, they nearly touch each other; the first and second are slightly farther apart, if anything, than the second and the third. Rollers one and three move from left to right, and the central roller in an opposite direction. The soap chips from the hopper pass between the first two rollers, forming a thin film on the under surface of the second roller; this film is further reduced in thickness by the pressure between rollers two and three. Clamped against the outer edge of the third roller is an iron comb, with teeth about ⅜ in. wide and the same distance apart, which divides the coating of soap, and throws it off in the form of narrow ribbons, which are caught by a wooden receptacle. The remaining coating on the roller is removed, and the roller entirely cleared from soap by means of a scraper clamped with its edge against the roller, and immediately beneath the comb.

Fig. 3 represents the bar-shaping or "plotting" machine, in which the ribbons from the milling machine are pressed into bars. In the interior of the cylinder is a spiral conical screw, with its threads in close contact with the surrounding casting; this screw is driven by gearing at a speed of about twenty revolutions per minute. The screw tapers from about 12 in. in diameter at the feeding end to about 6 in. at the ejecting end; the thread has seven turns in an entire length of about 15 in. Our engraving represents one of Messrs. Morane's machines with an ordinary, not a tapering, cylinder, but the machines are made in both forms, nd Messrs. Field prefer those which taper. On the ejecting end is screwed a removable disk, perforated as closely as possible with small holes about ⅛ in. in diameter, through which the soap is pressed after being fed along the spiral conical screw. Over this disk is screwed a nozzle, at the extremity of which is the aperture through which the soap is ultimately passed; a small place is left for compression between the perforated disk and the exit opening. In this space the cylinders of soap forced through the perforated disk are squeezed together, and as the cylinders meet, the pressure naturally forces them into hexagonal form, or the shape of the cell of the bee; cellulose cells seem to be naturally round, as in soft fruits like the strawberry; the hexagonal forms they take in parts of the shoots of the elder tree may be due to the same forces which produce the same forms in Messrs. Field's soap machine. The exit nozzle can be of any desired shape to give the desired form to the bar of soap.

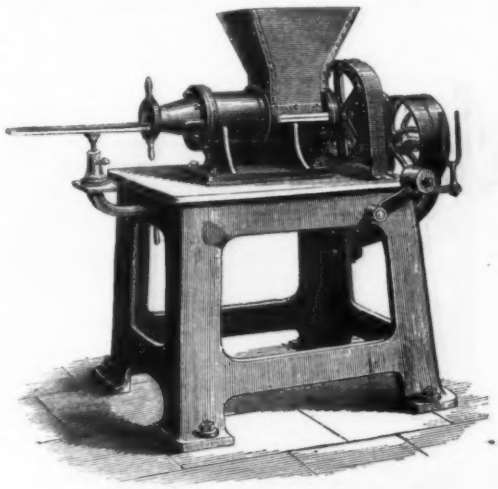


FIG. 3.—SOAP PRESSING MACHINE.

FIG. 4.—SOAP STAMPING MACHINE.

Fig. 4 represents the soap-stamping machine, in which blocks cut from the bars are stamped and lettered. Messrs. Field prefer a machine with a lever, rather than with a horizontal wheel, to apply the necessary force. Two rods attached to the stamping spindle pass down through the table of the stamping machine, and the cross-piece which unites them beneath carries in its center an upwardly projecting rod, which, under the control of a spring, serves, on the return of the upper die to its normal position, to loosen and nearly eject the soap tablet, the lower die being then ready to receive another block.

Fig. 5 represents one of the soap-mixing machines in use at the Battersea works In the trade it is known as a "soap-crutching" machine, no doubt in consequence of the primitive way of mixing soap having been by stirring it with an instrument resembling an inverted crutch, which instrument is still used at the Bermondsey works to stir finished soap while it is hardening into massive blocks. The Battersea machines were made by R. Houchin & Co., and consist of a steam-jacketed iron vessel of about 2½ ft. in diameter and 2⅛ ft. in depth, containing when full about 3½ cwt. of soap. The machine is set in motion by shifting the driving band from a loose to a fixed pulley, the axis of which carries slow speed gearing; the lowest wheel of the gearing has a shaft which passes loosely between two small beveled cog-wheels facing one another, both with a circular clutch on their inside faces. Between these two clutches, and mounted on the shaft, is a double-ended clutch which revolves with the gearing, but is capable of being guided along the shaft by means of a hand-lever loosely fitting it, so as to work with either one or other of the beveled cog-wheel clutches, and thus, since both the latter gear into a larger bevel wheel at right angles to them, effect the forward movement or reversal of the stirrer, which is carried by a spindle descending from the larger bevel wheel. Passing through a bearing in the center of the crosspiece of the machine, and through a stationary cog-wheel bolted thereto, the spindle terminates in a light crosspiece bearing the perforated U-frame, to one edge of which is fitted a scraper, which is in close contact with the pan during the entire revolution, and prevents any soap from sticking to it, the other edge of the scraper being a couple of inches away from the pan, and assisting to stir the soapy emulsion. When the pan is full, the frame is driven at about 15 revolutions per minute; the spiral-bladed twister travels the same number of times round the pan, and makes 60 revolutions on its own axis. The twister receives its motion from an arm fixed on the spindle holding the U-frame; this arm ends in a bearing, above which, and gearing at a slight angle into the aforementioned stationary cog-wheel, is a small spur-wheel, on the end of whose spindle is the spiral twister. Both the internal and external pans are of iron; steam at low pressure circulates between the two to keep the soapy emulsion at a temperature of about 200 deg. Fah.; any excess of pressure is relieved by a small safety valve.

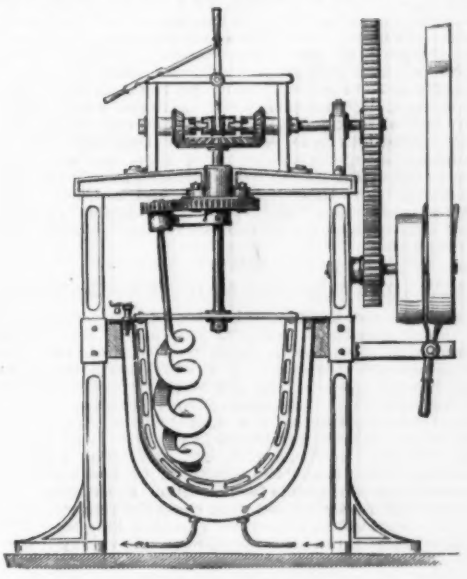


FIG. 5.—SOAP MIXING MACHINE.

Chevreul, whose brilliant discoveries in relation to the chemistry of the fatty acids did so much to establish the soap and candle making industries upon a scientific basis, is still living, and toward the close of this year will be one hundred years of age, when some kind of international centenary celebration is contemplated to be held in his honor. Michael Eugene Chevreul was born at Angers in 1786, and studied in Paris under Vauquelin. He became director of the dye works and professor of special chemistry at the Gobelins, where he studied the laws of the influence of adjacent colors upon the appearance of each other. The results of his researches were published with colored illustrations, and well deserve the perusal of those manufacturers who desire to produce the most pleasing effects with associated colors. His first scientific memoir was written so long ago as 1814–15. His discoveries in relation to the chemistry of the fatty acids were very complete; he was the discoverer of oleic acid, the basis of the fat oil soaps, a substance which, although so largely used in the crude form, can be prepared in the pure state only by troublesome chemical operations. It can be obtained from the fat of man or the fat of the goose, as well as from that of the ox, sheep, pig, and some other animals; it is present in animal fats, but in small proportion, but is plentiful in the non-drying vegetable oils. To obtain it pure, oil of almonds is saponified, the crude soap is decomposed by an acid, and the resulting oily acid is digested in a water bath for several hours with half its weight of oxide of lead; the mixture is then agitated with twice its volume of ether, and left for twenty-four hours, after which the clear solution is mixed with diluted hydrochloric acid, when the oleic acid rises to the surface dissolved in ether. The ether is removed by gentle evaporation, and the oleic acid again saponified by soda. It is then further purified by chemical means, and afterward by occasionally crystallizing it by cold at a temperature of about 20 deg. Fah., and separating the more impure portions by the aid of blotting paper. It is afterward crystallized from alcohol, and dried in a current of carbonic acid gas, for pure oleic acid absorbs oxygen somewhat freely. The pure acid is, at temperatures above 57 deg. Fah., a perfectly clear, colorless, oily liquid, without smell or taste. It does not redden litmus. It solidifies at 39 deg. Fah. or 40 deg. Fah., and below 39 deg. Fah. it is very hard. It is insoluble in water, soluble in alcohol and ether, and miscible with oils and fats; by absorption of oxygen it turns brownish yellow, and acquires a rancid smell. As an acid it is monobasic.—*The Engineer.*

A NEW SAFETY CARTRIDGE FOR COAL MINES.

A NEW safety cartridge for use in mines where it is not safe to blast with gunpowder has lately, says *Engineering*, been introduced in Germany by Dr. Kosmann, of Breslau. Its action depends upon the rapid liberation, in the bore-hole, of a large quantity of hydrogen gas, the pressure resulting from which

forces the coal or rock asunder. The hydrogen is liberated by means of the action of sulphuric acid upon very finely divided metallic zinc. For this purpose, Dr. Kosmann takes the bluish-gray powder that forms in the condensers of zinc distillation furnaces, and which consists of metallic zinc that has not been condensed to the liquid form, but results as a powder or as a more or less spongy mass. There is a small amount of oxide mixed with it, but for all practical purposes it may be considered as metallic zinc.

The cartridge consists of a glass cylinder, narrowing to a neck, and being also contracted at a point below the neck, so that the cylinder is divided into two portions, communicating through a contraction whose opening is from 8 mm. to 10 mm. The contraction is so placed that the two parts of the cylinder are to one another in cubic capacity as 1 to 4, the smaller part being near the neck of the cylinder. The lower or larger division is filled with sulphuric acid obtained by diluting the chamber acid of commerce with an equal volume of water. The contraction is then closed with a stopper of rubber or cork, and in this condition the cylinder is handed over to the miner. The hole being bored ready in the coal or rock, is well clayed over inside, in order to close any cracks or cavities through which gas could escape. The upper part of the glass cylinder is now charged with the zinc powder, and an iron rod is laid in, passing through the zinc and resting upon the stopper in the contracted part of the cylinder. The neck of the cylinder is then tightly plugged with clay, and it is laid in the hole, which is then also well tamped with clay, the iron rod passing through both these clay stoppings and projecting some little distance beyond.

In order to "fire the shot," the miner strikes the iron rod with a hammer, so as to drive in the stopper in the contracted part of the cylinder, or to break the glass at that part. In either case, the acid at once runs in among the zinc powder, and a very rapid evolution of hydrogen takes place. The iron rod is not uniform in thickness, but conical, being thicker toward the outside, and this increase of thickness is considerable, so that when the rod is driven in, it keeps tight in the clay stoppings and prevents any escape of gas.

The inventor gives figures to show that a cartridge 180 mm. long and 25 mm. in diameter, taking a charge of 50 cubic centimeters of acid and 12 grammes of the zinc powder, will give rise to an evolution of gas equal to 3·37 cubic meters at ordinary barometric pressure; and that the compression of this volume of gas into a space of 90 cubic centimeters means a pressure exerted on the sides of the hole equal to some 37,000 atmospheres. The pressure is obtained rapidly, but not so rapidly as to in any way endanger the man who drives in the rod. He has plenty of time to get away before any coal or rock comes down. It does not appear that these cartridges have yet had any thorough trial in practice, but much is expected of them, and the making of the cylinders has been intrusted to a large firm that will insure their being good and uniform. The cost of each "shot" will be from one penny to three half-pence, according to the size of the cylinder and charges used.

THERMOMETERS FOR HIGH TEMPERATURES.

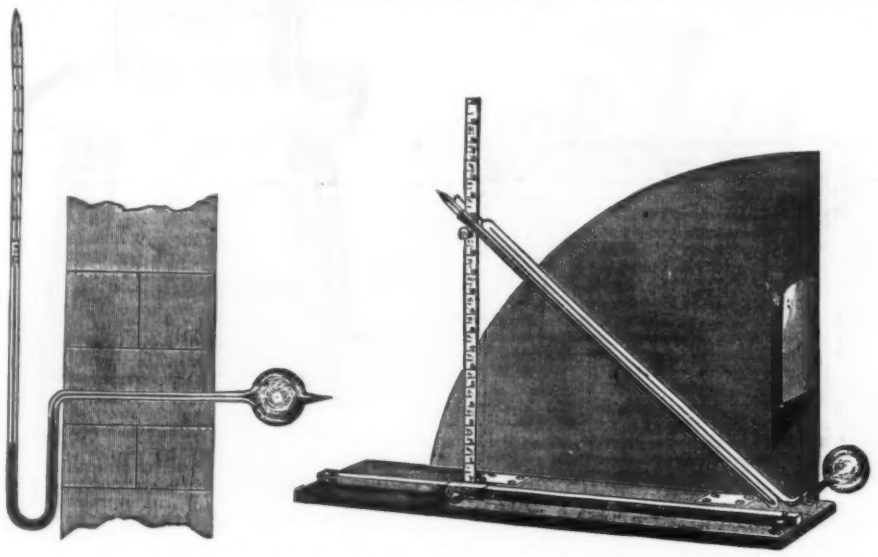
A THERMOMETER suitable for determining, with tolerable exactness, temperatures above the boiling point of mercury, and ranging up to a white heat, has long been a desideratum. It is well known that in gas making the temperature at which destructive distillation is carried on is a factor of superlative importance. In a paper relating to the manufacture of gas from oil, which was communicated to the Society of Chemical Industry in April, 1884, Dr. Armstrong comes to the conclusion that "the character of the hydrocarbons produced depends far less upon the character of the material decomposed than upon the temperature." To the same effect, if in more guarded language, Professor Lunge, in the introduction to his valuable work on "Coal Tar," says (referring to the temperature of distillation): "Probably this plays at least as important a part as the difference between the original materials." Seeing, then, that this matter of temperature is of so paramount importance, it is evidently necessary that, in order to determine correctly differences of degree, there should be some means available more scientific and precise than the common method of judging by color, yet simple in construction and easy of application. Hitherto the want has not been, or has been only partially, supplied. Siemens' electrical pyrometer, which is perhaps the most perfect instrument for determining high temperatures, is far too delicate and complicated for the purpose we have in view, viz., that of being used by ordinary workmen for every day needs. The water pyrometer (in which a current of water of known temperature flows at a constant rate through a coiled metallic tube placed in the space the temperature of which is required to be determined) is not altogether free from the same objections; and moreover, it is not so much adapted for indicating absolute as relative degrees of temperature.

The instrument which we illustrate—the invention of Messrs. Heisch and Folkard—is intended to meet the need of a thermometer for high temperatures at once simple and accurate. As will be seen from the engravings, there are two forms of the instrument—one for workmen, and the other for analytical chemists and others used to the manipulation of scientific instruments. In the former, the reading is taken in exactly the same way as with an ordinary mercurial thermometer; the temperature being indicated by the pressure of the air inclosed in a bulb, which is exposed to the source of heat, acting on a vertical column of mercury. The bulb may be of glass, porcelain, or platinum, according to the temperatures to be shown. By employing a platinum or porcelain bulb, the very highest temperatures can be indicated. One of the great advantages of the instrument is that the temperatures are seen at a glance without the time and manipulation required in using the Siemens or other pyrometer. The instrument, being hermetically sealed, is, of course, unaffected by changes in the height of the barometer.

The second form of the instrument is more complicated in construction, and enables greater exactness to be obtained; while its range is from the lowest attainable temperatures up to the softening point of the bulb. This instrument, like the other, is hermetically sealed; and, consequently, unaffected by barometric variations. It consists of a bulb of platinum or porcelain connected to a glass tube bent back on itself twice, and at right angles to the axis of the bulb. One end of the bent tube is pivoted on the base of the instrument, leaving the other end free to move up and down on a vertical scale, describing an arc round the pivot; and the vertical scale is made to move backward and forward on a horizontal rod, and can be fixed in any position by means of a set screw. By an easy adjustment, the pressure of the gas inclosed in a bulb exposed to the source of heat is measured in inches or millimeters on the divided scale. From the pressure thus measured, the temperature can at once be deduced—either graphically on millimeter paper, or by calculation. The pressure of the gas inclosed in the bulb is balanced by a column of mercury contained in the tube, the inclination of which can be varied. The resultant pressures are proportional to the sines of the angles of inclination of the mercurial column to the horizon, after allowing for capillarity; but, as stated above, these pressures are in practice read off on the graduated brass scale. An observation occupies about one minute; the manipulation being as follows: Level the base plate of the instrument; the bulb being exposed to the temperature to be measured, and the mercury tube being horizontal or nearly so. Raise the mercury tube slowly by means of the sliding-roller carriage on the brass scale, at the same time moving the scale along a horizontal brass rod as required, and gently tap the mercury tube. The column of mercury will descend in the tube, leaving a vacuum in the upper part. This raising of the tube is to be continued (tapping gently each time) until the top of the mercury is level with a standard mark on the tube. The gas in the bulb is now compressed to a definite volume by the inclined column of mercury, the vertical height of which represents the pressure. To graduate a new bulb, or verify an old one, immerse the bulb in melting ice or in the steam of boiling water, as may be most convenient, and read off on the brass scale the vertical height of the column of mercury required to compress the gas to the definite volume (*i. e.*, to the mark on the mercury tube) at 0° or 100° C., as the case may be. For example:

	Inches.
Vertical height of top of mercurial column at 100° C.	7·53
Vertical height of bottom of mercurial column at 100° C.	0·58
Pressure of gas in bulb at 100° C	6·95

Suppose now we wish to take the temperature of the vapor of boiling sulphuric acid. Observe the pressure in the same way as before, thus:



THERMOMETERS FOR HIGH TEMPERATURES.

	Inches.
Vertical height of top of mercurial column	11·73
Vertical height of bottom of mercurial column	0·63
Pressure of gas in bulb	11·10

And a simple calculation gives the temperature:

6·95 inches pressure = 100° C. What is the temperature at 11·10 inches?

$$695\,x = (1{,}110 \times 375) - (695 \times 375).$$
$$\therefore\ 695\,x = 416{,}250 - 260{,}625 = 155{,}625\ \therefore\ x = 224°.$$

A much simpler plan of deducing the temperature from the pressure is by construction on millimeter paper; for by calculating out two extreme temperatures (the ordinates representing the pressures and the abscissæ the number of degrees), and joining the tops of the two ordinates by a straight line, all the intermediate temperatures can be measured off in the ordinary way.

In very exact researches a small correction for capillarity must be made, the amount of which will depend on the diameter of the mercury tube and on the physical condition of the mercury itself. This is determined by the maker, once for all, before sealing off the bulb, by comparing the heights of the column in the mercury tube with the actual pressures shown on a manometer, also connected to the bulb. A new bulb and tube can be readily obtained in case of accident, and graduated as above. The illustration represents an instrument with 20 inch scale for gases and vapors. A modified form is made for use with liquids.—*Jour. of Gas Lighting.*

A SOLUTION of oxalic acid, citric acid, and tartaric acid will take out ink from paper, and may be applied upon the paper without fear of damage. Chloride of lime is also used.

[Continued from SUPPLEMENT, No. 548, page 8749.]

TELESCOPIC OBJECTIVES AND MIRRORS: THEIR PREPARATION AND TESTING.*

By HOWARD GRUBB.

Polishing Machines.—The two best known polishing machines are those of the late Earl of Rosse and the late Mr. Lassell, the general forms of which were shown in these diagrams. Time will not permit me to enter into a minute description of their working, nor is it necessary, as both have been often described.

A few words, however, as to the different character of the strokes given by these machines may be interesting. The stroke of Lord Rosse's machine may be imitated in hand work by the operator traversing the polisher or mirror in a series of nearly straight strokes, of about one-third the diameter of the glass, to and from himself, at the same time that he keeps walking slowly round the post; and instead of allowing the center of polisher to pass directly over center of mirror, each stroke that he gives he slides a little (about one-tenth diameter) to o e side and then a little to the other.

Mr. Lassell's stroke may be imitated by causing the polisher to describe a series of nearly circular strokes a little out of the center, walking around the post at the same time; thus the center of polisher will describe a series of epicycloidal or hypocycloidal curves on the speculum.

Many years ago my father devised a machine, figured and described in Nichols' "Physical Science," by which either of these motions could be obtained. He appeared to have got better results with Mr. Lassell's strokes, for he afterward devised a machine which gave the same character of stroke, but over which the operator had greater control, and this machine has been used for many years with great success. Like all machines, however, which give a series of strokes constantly recurring of the same amplitude, it is apt to polish in rings. It is impossible to obtain absolute homogeneity in the pitch patches, and if any one square be a shade harder than the general number, and that square ends its journey at each stroke at the same distance from the center of speculum or glass, there will almost surely be a change of curvature in that zone. To avoid this, I have made a slight modification in the machine, which has increased its efficiency to a great extent. I will now place in the lantern a model of this machine, and first draw you a few curves with the machine in its old state, and afterward in its improved state.

In order to convey some idea of the relative quantities of material removed by the various processes, I have placed upon the walls a diagram which will illustrate this point in two distinct ways.

The diagram itself represents a section of a lens of about 8 inches aperture and 1 inch thick, magnified 100 times, and shows the relative thickness of material abraded by the four processes.

The quantity removed by the rough grinding process is represented on this diagram by a band 25 inches wide, the fine grinding by one $\frac{8}{10}$ inch wide, the polishing by a line $\frac{1}{16}$ inch wide, while the quantity removed by the figuring process cannot be shown even on this scale, as it would be represented by a line only $\frac{1}{1000}$ inch thick.

I have also marked on this diagram the approximate cost of abrasion of a gramme of material by each of the four processes, viz.:

	£	s.	d.	
Rough grinding, about	0	0	1	per gramme.
Fine grinding, "	0	0	7½	"
Polishing, "	0	10	0	"
Figuring, "	48	0	0	"

Figuring and Testing.—By the figuring process I mean the process of correcting local errors in the surfaces, and the bringing of the surfaces to that form, whatever it may be, which will cause the rays falling on any part to be refracted in the right direction. When an objective has undergone all the processes I have described, and many more which are not so important, and with which I have not had time to deal, and when the objective is centered and placed in its cell, it is, to look at, as perfect as it will ever be, but to look through and use as an objective it may be useless. The fact is that when an objective has gone through all the processes described, and is, in appearance, a finished instrument, I look upon it as about one-fourth finished. Three-fourths of the work has probably to be done yet. True, sometimes this is by no means the case, and I have had instances of objectives which were

* Lecture given at the Royal Institution on Friday, April 2, 1886, by Mr. Howard Grubb, F.R.S., F.R.A.S.

perfect on the first trial; but this is, I am sorry to say, the exception and not the rule.

This part of the process naturally divides itself into two distinct heads:

1. The detection and localization of faults—what may, in fact, be termed the diagnosis of the objective.

2. The altering of the figures of the different surfaces to cure these faults. This may be called the remedial part.

It may be well here to try to convey some idea of the quantities we have to deal with, otherwise I may be misunderstood in talking of great and small errors.

I have before mentioned that it is possible to measure with the spherometer quantities not exceeding $\frac{1}{250000}$ of an inch, or with special precaution much less even than that; but useful as this instrument is for giving us information as to the general curves of the surface, it is utterly useless in the figuring process; that is, an error which would be beyond the power of the spherometer to detect would make all the difference between a good and a bad objective.

Take actual numbers, and this will be evident. Take the case of a 27 inch objective of 34 ft. focus; say there is an error in center of one surface of about 6 inches diameter, which causes the focus of that part to be $\frac{1}{10}$ of an inch shorter than the rest.

For simplicity's sake, say that its surface is generally flat; the center 6 inches of the surface therefore, instead of being flat, must be convex, and of over 1,000,000 inches radius. The versed sine of this curve, as measured by spherometer, would be only about $\frac{1}{250000}$, 4 millionths of an inch, a quantity mechanically unmeasurable, in my opinion.

If that error was spread over 3 inches only instead of 6 inches, the versed sine would only be about $\frac{1}{1000000}$. Probably the effect on the image of this 3 inch portion of $\frac{1}{10}$ inch shorter focus would not be appreciable on account of the slight vergency of the rays, but a similar error near edge of objective certainly would be appreciable. Until, therefore, some means be devised of measuring with certainty quantities of 1 millionth of an inch and less, it is useless to hope for any help from mechanical measurement in this part of the process.

If, then, no known mechanical arrangement be delicate enough to measure these quantities, how, it may be asked, are these errors detected?

The answer to this is, that certain optical arrangements enable us to carry our investigations far beyond the limits of mechanical accuracy. Trials of the objective or mirror as a telescope are really the crucial test, but there are various devices by which defects are detected and localized.

The best object to employ is generally a star of the third or fourth magnitude, when such is available; but as it frequently occurs that no such object is visible, recourse is had to artificial objects. The minute image of the sun reflected from little polished balls of speculum metal, or even a thermometer bulb, is a very good object; polished balls of black glass are also used with good effect; but as the sun is also of somewhat fickle disposition in this country, we have frequently to have recourse to artificial light. Small electric lamps, such as this, with their light condensed and thrown on a polished ball, are very useful. In fact, I am never without one of them in working order.

For the detection and localization of error, it is very useful to be provided with sets of diaphragms which leave exposed various zones of the surface, the foci of which can then be separately measured, but a really experienced eye does not need them.

For concave surfaces, Foucault's test is useful. I shall not trespass on your time to explain this in detail, as it is described very fully in many works, in none better than in Dr. Draper's account of the working of his own reflecting telescope. This diagram will give an idea of the principle of the system, which is really the same as what I have described as useful for detecting want of homogeneity in the substance of the glass.

This system is extremely useful for concave spherical surfaces, but is not available for convex surfaces, and only partially available for concave parabolic surfaces.

The really crucial test is, as I said before, the performance of the objective when used as a telescope; and the appearance of the image not only at the focus, but on each side of it, conveys to the practiced eye all the information required for the detection of the errors.

If an objective have but one single fault, its detection is easy; but it generally happens that there are many faults superposed, so to speak. There may be faults of achromatism, and faults of figure in one or all the surfaces; faults of adjustment, and, perhaps, want of symmetry from some strain or flexure; and the skill of the artist is often severely taxed to distinguish one fault from the rest and localize it properly, particularly if, as is generally the case, there be also disturbances in the atmosphere itself, which mask the faults in the objective, and permit of their detection only by long and weary watching for favorable moments of observation.

It would be impossible in one or a dozen of such lectures as this to enumerate all the various devices that are practiced for the localization of errors, but a few may be mentioned, some of which have never before been made public.

For detection of faults of symmetry, it is usual to revolve one lens on another and watch the image. In this way it can generally be ascertained whether it is in the flint or crown lens.

With some kinds of glass the curves necessary for satisfying the conditions of achromatism and spherical aberration are such that the crown becomes an equi-convex and the flint a nearly plano-concave of same radius on inside curve as either side of the crown. This form is a most convenient one for the localization of surface errors in this manner.

The lenses are first placed in juxtaposition and tested. Certain faults of figure are detected. Now, calling the surfaces A, B, C, D, in the order in which the rays pass through them, place them again together with Canada balsam or castor oil between the surfaces, B and C, forming what is called a cemented objective. If the fault be in either A or D surface, no improvement is seen; if in B or C, the fault will be much reduced or modified. Now reverse the crown lens, cementing surfaces A and C together. If same fault still shows, it must be in either B or D. If it does not show, it will be in either A or C. From these two experiments the faults can be localized.

It often happens that a slight error is suspected, but its amount is so slight that it appears problematical whether an alteration would really improve matters or not. Or the observer may not be able to make up his mind as to the exact position of the zone he suspects to be too high or too low, and he fears to go to work and perhaps do harm to an objective on which he has spent months of labor, and which is almost perfect. In many such cases I have wished for some means by which I could temporarily alter the surface, and see it so altered before actually proceeding to abrade and perhaps spoil it.

During my trials with the great objective of Vienna, I thought of a very simple expedient, which effects this without any chance at all of injuring the surface. If I suspect a certain zone of an objective is too low, and that the surface might be improved by lowering the rest of it, I simply pass my hand, which is always warmer than the glass, some six or eight times round that particular zone. The effect of this in raising the surface is immediately apparent, and is generally too much at first, but the observer at the eye end can then quietly watch the image as the effect goes off, and very often most useful information is thus obtained. The reverse operation, that of lowering any required part of the surface, is equally simple. I take a bottle of sulphuric ether and a camel's hair brush, and pass the brush two or three times round the part to be lowered, blowing on it slightly at the same time; the effect is immediately perceived, and can always be overdone if required.

So far then for the diagnosis. Now for the remedy. When the fault has been localized, the lens is again put upon the machine and the polisher applied as before, the stroke of the machine and the size of the pitch patches being so arranged as to produce, or tend to produce, a slightly greater action on those parts that have been found to be too high (as before described while treating of the polishing processes).

The regulation of the stroke, eccentricity, speed, and general action of the machine, as well as the size and proportion of the pitch squares, and the duration of the period during which the action is to be continued, are all matters the correct determination of which depends upon the skill and experience of the operator, and concerning which it would be impossible to formulate any very definite rules. All thanks are due to the late Lord Rosse and Mr. Lassell, and also to Dr. De la Rue, for having published all particulars of the process which they found capable of communication; but it is a notable fact that, as far as it is possible to ascertain, every one who has succeeded in this line has done so, not by following written or communicated instructions, but by striking out a new line for himself; and I think I am correct in saying that there is hardly to be found any case of a person attaining notable success in the art of figuring optical surfaces by rigidly following directions or instructions given or bequeathed by others.

There is one process of figuring which is said to be used with success among Continental workers. I refer to the method called the process of local touch. In this process those parts, and those parts only, which are found to be high, are acted upon by a small polisher.

This action is of course more severe; and if only it were possible to know exactly what was required, it ought to be much quicker; but I have found it a very dangerous process. I have sometimes succeeded in removing a large lump or ring in this way (by large, I mean 3 or 4 millionths of an inch), but I have also, and much oftener, succeeded in spoiling a surface by its use. I look upon the method of local touch as useful in removing gross quantities, but for the final perfecting of the surface I would not think of employing it.

In small sized objectives the remedial process is the most troublesome, but in large sized objectives the diagnosis becomes much the more difficult, partly on account of the rare occurrence of a sufficiently steady atmosphere. In working at the Vienna objective, it often happened when the figure was nearly perfect that it was dangerous to carry on the polishing process for more than ten minutes between each trial; and we had then, sometimes, a week to wait before the atmosphere was steady enough to allow of an observation sufficiently critical to determine whether that ten minutes' working had done harm or good.

It must not be supposed either that the process is one in which improvement follows improvement, step by step, till all is finished. On the contrary, sometimes everything goes well for two or three weeks, and then, from some unknown cause, a hard patch of pitch perhaps, or sudden change of temperature, everything goes wrong. At each step, instead of improvement there is disimprovement, and in a few days the work of weeks, or months perhaps, is all undone. Truly, any one who attempts to figure an objective requires to have the gift of patience highly developed.

In view of the extraordinary difficulty in the diagnostic part of the process with large objectives, it is my intention to make provision which I hope may reduce the trouble in the working of the new 28 inch objective for the Royal Observatory, Greenwich.

Two of the greatest difficulties we have to contend with are: (1) the want of homogeneity in the atmosphere, through which we have to look in trials of the objective, due to varying hygrometric and thermometric states of various portions; and (2) sudden changes of temperature in the polishing room. The polisher must always be made of a hardness corresponding to the existing temperature. It takes about a day to form a polisher of large size, and if before the next day the temperature changes 10° or 15°, as it often does, that polisher is useless, and a new one has to be made, and, perhaps, before it is completed another change of temperature occurs. To grapple with these two difficulties, I propose to have the polishing chamber under ground, and, leading from it, a long tunnel formed of highly glazed sewer pipes about 350 feet long, at the end of which is placed an artificial star illuminated by electric light; on the other side of the polishing chamber is a shorter tunnel, forming the tube of the telescope, terminating in a small chamber for eye-pieces and observer. About half way in the long tunnel there will be a branch pipe connected to the air-shaft of the fan, which is used regularly for blowing the blacksmith's fire, and through this, when desired, a current of air can be sent to "wash it out" and mix up all currents of varying temperature and density. It may be found necessary even to keep this going during observations.

By this arrangement I hope to be able to have trials whenever required, instead of having to wait hours and days for a favorable moment.

Figuring of Plane Mirrors.—There is a general idea that the working of a plane mirror, or one of very long radius, is a more difficult operation than those of more ordinary radii. This is not exactly the case. There is no greater difficulty in figuring a low curve than a deep one, but the difficulty in the case of absolutely plane mirrors consists simply in the fact that in their figuring there is one additional condition to be fulfilled, viz., that the general radius of curvature must be made accurate within very narrow limits. In figuring a plane mirror to use, for instance, in front of even a small objective, say 4 inch aperture, an error in radius which would cause a difference of focus of $\frac{1}{10}$ of an inch would seriously injure the performance. This would be about equivalent to saying that the radius of curvature of the mirror was about 8 miles, the versed sine of which, with the 6 inch spherometer, would be about $\frac{1}{250000}$ of an inch. Now what I mean to convey is this: that it would be just as difficult to figure a convex or concave lens of moderate curvature as a flat lens of the same size if it were necessary to keep the radius accurate to that same limit, *i. e.*, one-tenth of a division of this spherometer.

Lick Observatory.—For the final testing of large objectives or mirrors, it is necessary to have them properly mounted, and in such a manner that they can be directed conveniently on any celestial object, and kept so directed by clockwork, to enable the observer to devote his whole attention to the testing. I had not intended touching at all on the subject of the mounting of telescopes, but I have been asked to call your attention to this model of a proposed observatory for Mount Hamilton, California, as it embraces some novel features, but I shall do so in only a very few words.

Most here are probably aware that a monster observatory is in course of erection in California, a large sum of money having been left for the purpose by a Mr. Lick. The observatory is already partly complete, and contains some excellent instruments of moderate size, the work already done with which warrants us to hope that the great 36 inch refractive about to be erected will be placed under more favorable conditions for work than any other large telescope in the world.

The 36 inch objective is at present in process of construction by the Messrs. Clark, of America, but the mounting has not yet been contracted for.

Some years since, in a paper published in the *Transactions* of the Royal Dublin Society, I shadowed forth a principle which I considered should be adopted in great telescopes of the future. The trustees of the Lick Observatory having invited me to design an instrument for the 36 inch objective, I have put into practical form what I had before given but general principles of, and the design which this model illustrates is the result.

Whether this design will ever be carried out or not I cannot tell, but even as a proposal I trust it may be interesting enough to excuse my introducing it (somewhat irrelevantly perhaps) to your notice to-night.

The design includes the equatorial itself, with its observatory, dome, and provision for enabling the observer to reach the eye end conveniently.

The conditions I laid down for myself in designing this observatory were that it would be possible for the observer single-handed to enter the equatorial room at any time, and that, without using more physical exertion than is necessary for working the smallest sized telescope, or even a table microscope, he should be able to open the 70 foot dome, turn it round backward and forward, point the equatorial to any part of the heavens, revolving it in right ascension and declination to any extent, and finally (the most difficult of all) to bring his own person into a convenient position for observing. I say this last is the most difficult of all, for I think any who have worked with larger instruments will allow that there is generally far more trouble in moving the observatory chair (so called) and placing it in proper position than in pointing the instrument itself. In this instrument the "chair" would require to be 25 feet high, and with its movable platform, ladder, balance weight, etc., would weigh probably some tons. Even if very perfect arrangements were made for the working of this chair, the mere fact that the observer, while attempting to make the most delicate observations, is perched upon a small and very unprotected platform 25 feet above the floor, and in perfect darkness, tends to reduce his value as an observer to an extent only to be appreciated by those who have tried it.

No matter how enthusiastic a man may be at his work, I would not put a high value on his determinations if made while in a position which calls for constant anxiety for his own personal safety. I would go even further still, and say that even personal comforts or discomforts have much to do with the value of observations.

I propose, therefore, that all the various motions should be effected by water power. There are water engines of various forms now made, some of which have no dead point, and, having little *vis inertia*, are easily stopped and started, and are consequently well adapted for this work.

I propose to use four of them—one for the right ascension motion of the instrument, and one for the declination; one for revolving the dome, and one for raising and lowering the observer himself; but instead of having anything of the nature of a 25 foot chair or scaffold, I propose to make the 70 foot floor of the observatory movable. It is balanced by counterpoise weights, and raised and lowered at will by the observer. Then the observer can without any effort raise and lower the whole floor, carrying himself, and twenty people if desired, to whatever height is most convenient for observation; and wherever he is observing, he is conscious that he has a 70 foot floor to walk about on, which even in perfect darkness he can do in safety.

The valves and reversing gear of the water engines are actuated by a piece of mechanism, the motive power of which may be a heavy weight raised into position some time during the previous day by man or water power. By means of a simple electrical contrivance, this piece of machinery itself is under the complete control of the observer, in whatever part of the room he may be, and he carries with him a commutator of a compact and convenient form, with eight keys in four pairs, each pair giving forward and back-

ward movements respectively to: A, telescope movement in right ascension; B, telescope movement in declination; C, revolution of dome; D, raising of floor.

The remaining operation—opening of shutter—is easily effected without any additional complication.

It is only necessary to anchor the shutter (which moves back horizontally) to a hook in the wall and move the dome in the opposite direction by motion C; the shutter must, of course, be opened by this motion. . . .

It is very possible that there may be some here who have found what I have had to say on the subject of the figuring of objectives very unsatisfactory. They may have expected, naturally enough, that, instead of treating of generalities to such a large extent as I have done, I should have given precise directions, by the following of which rigidly any person could make a telescopic objective.

To those, however, who have followed me in my remarks, the answer to this will probably have already suggested itself. It is the same answer which I give to those who visit my works and ask what the secrets of the process are, or if I am not afraid that visitors will pick up my secrets. All the various processes which I have described up to that of the figuring are, I consider, purely mechanical processes, the various details of which can be communicated or described as any mechanical process can be; but in the last final and most important process of all there is something more than this. A person might spend a year or two in optical works where large objectives are made, and might watch narrowly every action that was taken, see every part of the process, take notes, and so forth, and yet he could no more expect to figure an objective himself than a person could expect to be able to paint a picture because he had been sitting in an artist's studio for the same time watching him at his work. Experience, and experience only, can teach any one the art, and even then it is only some persons who seem to possess the power of acquiring it.

A well known and experienced amateur in this work declared his conviction that no one could learn the process under nine years' hard work, and I am inclined to think his estimate was not an exaggerated one.

True, it may be said that large objectives can be and are generally turned out by machinery, but what kind of an objective would any machine turn out if left to guide itself, or left to inexperienced hands?

At the risk of being accused of working by what is generally called the rule of thumb, I confess that conditions often arise, to meet which I seem to know intuitively what ought to be done, what crank to lengthen, what tempering is required of the pitch square; and yet if I were asked I should find it very hard to give a reason for my so doing which would even satisfy myself.

I may safely say that I have never finished any objective over ten inches diameter, in the working of which I did not meet with some new experience, some new set of conditions which I had not met with before, and which had then to be met by special and newly-devised arrangements.

A well-known English astronomer once told me that he considered a large objective, when finished, as much a work of art as a fine painting.

I have myself always looked upon it less as a mechanical operation than a work of art. It is, moreover, an art most difficult to communicate. It is only to be acquired by some persons, and that after years of toilsome effort, and even the most experienced find it impossible to reduce their method to any fixed rules or formulæ.

DOMESTIC ELECTRICITY.

ALL those who use the Leclanché pile for actuating electric bells have appreciated the incomparable advantages of this generator of electricity, which is one that requires no watching and no care, and which is ever ready to operate. This pile, on the contrary, becomes easily and quickly polarized when it is run continuously, and so, up to the present, the use of it for lighting has been out of the question.

Mr. Goodwin, an American manufacturer of carbon for piles and arc lamps, has recently introduced some happy improvements into the apparatus that permit him to obtain remarkable results as regards intermittent electric lighting.

The porous vessels or agglomerated disks of the ordinary form of the pile are replaced by a carbon vessel whose sides are rendered very porous. The interior of this is filled with cracked carbon and peroxide of manganese. The feeble internal resistance of the couple permits of a large discharge, and hence the use of it in the production of electric light.

A larger duration of the lighting is obtained by the selection of vessels whose surface is rendered wider by ribs, as shown in the annexed figure.

A few months ago we described in this place Mr. Radiguet's system of electric lighting, which we had ordered put into a portion of our apartments, and which is still operating with regularity and to our satisfaction. Always anxious to keep ourselves conversant with new applications, we have, on the other hand, adopted the new system of lighting by Leclanché piles devised by Messrs. Buchin & Tricoche, and we are getting a very brilliant but intermittent light, lasting but a short time, and produced at spaced intervals. The result is none the less interesting in practice.

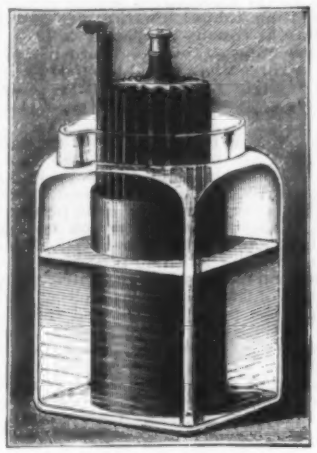
Our plant comprises 40 couples of the Goodwin pile, mounted by twenties for tension and by twos for quantity. The incandescent lamps, of from 8 to 10 candle power, give a beautiful light, which begins to weaken in a few minutes, but which still remains brilliant enough for from fifteen to twenty minutes. When once the circuit is broken, the pile becomes depolarized, and is soon ready to operate again as before.

Messrs. Buchin & Tricoche have devised some ingenious combinations that permit them to light or extinguish lamps from a distance. In the rooms in which we have placed incandescent lamps, a commutator permits of lighting the room upon entering it and of extinguishing the lamp upon leaving it, and *vice versa*.

This intermittent system is very useful in badly lighted rooms, passages, bed rooms, and other places. The light produced under such conditions would seem to be economical. According to the inventor, it does not cost one-fifth of a cent per candle-power per hour, a wear of the piles occurring only in proportion to the work furnished. About every six months it is necessary to replenish the piles with water and sal ammoniac, and to clean the zincs. The same battery will serve for electric bells, and can be applied to automatic gas lighters.

The method of electric lighting that we are now describing is still far from being perfect, since the light is intermittent, but it certainly offers very great advantages in certain particular cases, and presents itself as one process more to select from among the existing systems. An undoubted progress has here been made, for which we congratulate the promoters.

A large number of persons might desire to have more, and to have at their disposal, in their houses or apartments, a permanent electric light operating continuously for several consecutive hours. It appears to us that it will be difficult for primary piles to give a solution of this problem; secondary ones, which are true reservoirs of electricity, are better adapted for furnishing the elements of it. The electric light plant which our collaborator and friend, Mr. E. Hospitalier, has organized in his apartments, and which comprises a battery of accumulators constantly charged by means



of bichromate piles of continuous flow, is giving good results, but it requires a certain surveillance.

The problem of domestic electricity will be solved only by the distribution of electricity to dwellings.—*La Nature.*

A NEW AND ORIGINAL METHOD OF SURGICAL DRESSING.

DR. CHARLES W. STROBELL, of Middletown Springs, Vt., writes that he was led by the paper of Dr. Hamilton, and the criticisms upon it in recent numbers of the *Record*, to consider what improvements might be made upon the modes of antiseptic dressing now in use. The main objection to the ordinary dressings of cotton-wool, gauze, etc., is that it conceals the wound from view, so that inflammation, secondary hemorrhage, and other accidents cannot be detected at their onset, and may become only too well established before the surgeon becomes aware of their existence. In order to obviate this, Dr. Strobell proposes to cover the wound with a thin glass globe, so constructed as to fit closely to the part, provided with two openings for drainage tubes, and a large opening on the top to permit of access to the wound, in case of need, without removing the globe. These openings are provided with glass stoppers, so that they can be hermetically closed. The base of the globe is provided with a flange, and its sides, up to within two inches of the drainage tube openings, are roughened so as to facilitate the adhesion of the isinglass plaster used in sealing it. When applied to stumps after amputation, a thin rubber band, three inches wide, is applied over the flange, so that it rests with one-half its width on the integument of the limb to secure additional safety. The flange is covered on its external surface with isinglass plaster, adhesive on both sides, so that the band of rubber shall adhere firmly to the globe. In the case of an amputation at the knee-joint, after the sutures and drainage tubes are in place, the wound is capped with a disinfected globe of the proper size to fit snugly over the limb, the drainage tubes in the globe being on a line with the anterior surface of the wound. The rubber band is now turned down over the limb, and strips of adhesive silk, one inch in width and twelve inches in length, are applied longitudinally from the upper part of the ground portion of the globe up the limb, each strip overlapping slightly the preceding one, a final strip being placed circumferentially around the flange, and covering in the ends of the longitudinal ones. In a case of laparotomy, an oval-shaped globe may be applied in a similar manner.

The following are the conclusions of the writer:

"The method commends itself to the profession: 1. In the complete isolation of wounds that can be obtained in the event of infection of hospital wards by erysipelas, etc., as the globe can be hermetically sealed. 2. All changes can be noted clearly at any moment with the minimum amount of discomfort to the patient, thereby increasing largely his chances of recovery. 3. The perfection of drainage, which has never been obtained in so great a degree, obviating the necessity of soaking off bandages saturated with dried pus, blood, and serum, often adhering so firmly to the wound that the most gentle manipulation is required to avoid laceration of the tender granulations. 4. Secondary hemorrhage can be detected at the earliest possible moment. 5. The first evidence of inflammation can be noted, and its movement forestalled by removal of the cause. 6. The action of topical remedies can be observed without exposure of the wound to the air. 7. The dressing can be adapted to wounds of almost every description. 8. Refrigerant and thermal water-dressings can be applied with the utmost facility. 9. Lotions or powders can be easily applied to the wound through the main opening in the globe without disturbing the dressings. 10. If it is desired to prevent the ingress of infected air, the drainage tubes can be filled with plugs of iodoformed or carbolized cotton. 11. In the event of inflammatory swelling rendering the constriction of the base of the globe excessive, the apparatus can be replaced by one of larger size with less expenditure of labor and time than is required in the application of a Lister dressing. 12. Facility is afforded for determining the therapeutic effect and germicidal action of direct sunlight in the treatment of wounds. 13. By means of long, slender forceps and scissors, the sutures, drainage tubes, and adhesive plaster may be easily removed through the main aperture in the globe. 14. The weight of the apparatus is not as great as that of the ordinary Lister dressing. 15. If perfectly applied, there should be no more constriction of the limb than results from moderately firm bandaging. 16. The expense is comparatively light, as the globes can be used indefinitely, being thoroughly disinfected by boiling water. 17. The apparatus may be adapted to any external surface by taking, in special cases, wax impressions and transmitting them to the manufacturer. In conclusion, I will say that my claim to originality is, in my opinion, well founded, as nowhere in surgical works have I seen glass mentioned, used in the way I have indicated, as a protective dressing."—*Medical Record.*

MEDICO-LEGAL RESEARCHES ON THE BLOOD.

MEDICO-LEGAL researches on the blood are based principally upon the chemical and optical properties of its coloring matter, that is to say, oxyhemoglobine and its derivatives. Before describing the new instrument that gives absolutely unlooked for resources of precision and delicacy, we shall have a few words to say concerning the method of chemical research, reserving to ourselves the pleasure of giving fuller details as to spectral research, which, up to the present, is the surest and most accurate method, and the one most employed.

Oxyhemoglobine, which was formerly called globuline, hematosine, hematine, hemato-crystalline, hematoglobuline, cruorine, etc., is a crystallizable substance containing iron and oxygen, with which it is so feebly combined that it gives up the latter to various reducing agents, and thus becomes converted into a new coloring matter, reduced hemoglobine, which is likewise crystallizable.

The coloring matter of blood varies with the species of animal. The aspect of oxyhemoglobine crystals, their solubility, and the proportion of water of crystallization that they contain, are so many things that argue in favor of the opinion now generally adopted, which admits several varieties (probably as many as there are kinds of blood) of oxyhemoglobine and hemoglobine. Thus, in man, oxyhemoglobine exhibits itself under the microscope in the form of elongated rectangles, rhombs (angle 54° 6'), and 4-sided prisms; in the monkey, in small rhombic tablets; in the hedgehog, in elongated rectangular prisms; in the lion and cougar, in 4-faced prisms ending in two oblique faces; in the Guinea-pig, in tetrahedrons, whose angles differ little from 60°; in the raven and pigeon, in sphenoids; in the marmot, sheep, hog, python, frog, roach, pike, and horse-leech, in prisms; and, finally, in the perch, turtle, earth-worm, and sparrow, in needles of varying slenderness.

We would add that oxyhemoglobine crystals possess constant properties. They behave in the same way with oxygen and oxide of carbon; their optical properties are alike; they exhibit double refraction and are polychroic; and, placed in front of the slit of a spectroscope, they show identical absorption bands. We shall have occasion to advert more than once to this latter important character.

Oxyhemoglobine, when dried in a vacuum under 0°, appears in the form of a light red crystalline powder, soluble in water, which it tinges blood-color. It has been ascertained by Claude Bernard that carbonic oxide quickly expels the oxygen that is feebly combined with oxyhemoglobine, and forms a combination of crystalline oxycarbonated oxyhemoglobine. According to Hüfner, 100 grammes (3½ ounces) of hemoglobine fix 159·2 cubic centimeters (9¾ cubic inches) of carbonic oxide at 0° and under a pressure of 760 millimeters (29½ inches). Such stability explains the rapidly fatal action of the carbonic oxide which is emitted from charcoal furnaces, and which plays so great a role in accidental or voluntary asphyxia. Substances that combine freely with oxygen, such as ammonium sulphide, iron by hydrogen, ferrous sulphate, etc., convert oxyhemoglobine into reduced hemoglobine. Advantage is taken of this property in legal medicine.

It is almost useless to speak of the importance that a legal research on blood might possess in the case of a murder, where the expert charged by the court to ascertain whether the spots found upon the garments, floor, knife, or other weapon, were really blood stains, did not feel that he was in possession of accurate enough methods to allow him to solve a grave question upon which depended a man's life.

Three methods offer themselves: The first and surest is that which consists in examining the blood directly in the microscope. If the globules are distinctly seen, it is very evident that any subsequent research will be useless; but, unfortunately, such a case, so to speak, never presents itself, for the spots in most instances are more or less old, and have been washed, or are mixed with rust or with the coloring matter with which the clothing was dyed. Under these circumstances it becomes necessary to have recourse either to chemical research or to spectroscopy.

The chemical method, which was first pointed out by Teichmann, and afterward modified by Hoppe-Seyler, Brucke, and Erdmann, consists in treating the substance to be examined with a trace of kitchen salt and a drop of concentrated acetic acid. This operation is performed upon a microscope slide, and after the preparation has been gently heated for an instant in order to dissolve the substance and evaporate the liquid, the slide is placed under the microscope, and, under an amplification of from 300 to 500 diameters, there are observed small, brown, rhomboidal crystals of hydrochlorate of hematine, called hemine by Teichmann. This reaction, which is simple in appearance, is in reality subject to many causes of error. If too much chloride of sodium be added, we obtain crystals which are not those of the blood; if the blood has putrefied before becoming dry, when the spot is mixed with the substances that form insoluble combinations with

hematine, the reaction takes place with difficulty; and if the fabric has been dyed with indigo, this substance, with acetic acid, gives crystals that may be confounded by a tyro in this kind of research with hydrochlorate of hematine.

These different objections have caused the gradual abandonment of this method, although it once had great renown, and now, in order to determine whether or not a spot has been produced by blood, it is dissolved out by water, and the colored liquid is examined with the spectroscope.

As demonstrated by Newton, the solar spectrum is formed of seven colors, placed in the following order: red, orange, yellow, green, blue, indigo, violet. In 1802, Wollaston remarked that these colors were accompanied with a very large number of dark, slender lines parallel with the edges of the prism, and unequally spaced. Fraunhofer was the first (in 1815) to study

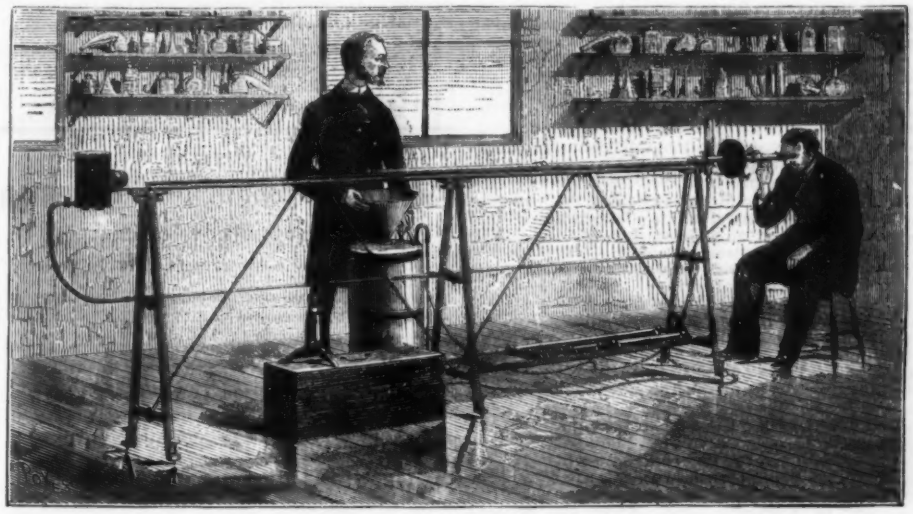


FIG. 1.—DE THIERRY'S GREAT ABSORPTION SPECTROSCOPE.

these with care, and to give a detailed description of them. He designated the most apparent of these lines (which are usually called "Fraunhofer lines") by the letters A, *a*, B, C, D, E, *b*, F, G, H—the line A being at the limit of red and orange, D being in the yellow, E in the green, F in the blue, G in the indigo, and H in the violet.

The spectrum analysis of blood is based upon the property possessed by colored bodies of absorbing certain of the irradiations of white light. A red object appears red to us precisely because it absorbs all the colored rays save the red ones; and if we put this red object in front of the slit of a spectroscope, and observe the spectrum formed, either upon a screen or with a spy-glass, we shall see that all the rays are arrested save the red, and that their places are marked by as many dark bands, whose position can be exactly determined by a micrometer. These have received the name of absorption bands. They are characteristic of the substance that produces them, and thus allow of ascertaining its presence when they appear. Hoppe-Seyler, when professor at Tubingen, in 1862, was the first to publish the fact that blood, when observed in the spectroscope, presents a spectrum interrupted by two broad, dark bands whose position is constant and invariable. The Hoppe-Seyler bands are both situated between lines D and E of the solar spectrum; and to them must be added another, discovered by Mr. Soret in the violet. Hoppe-Seyler likewise discovered that the spectrum of blood was the same, whether the latter was examined in a pure state diluted with water, or whether an aqueous solution of oxyhemoglobine was examined; and he observed that the spectrum was

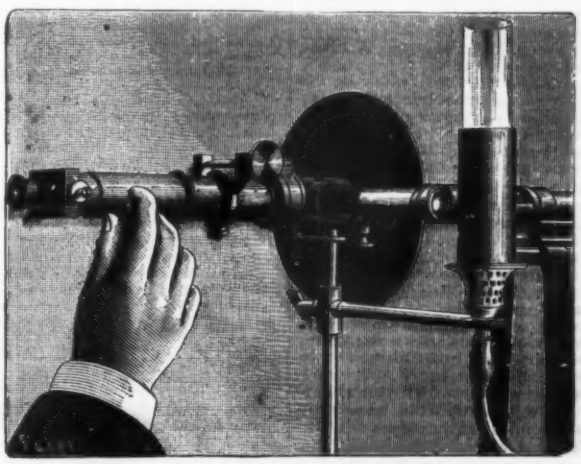


FIG. 2.—FRONT PART OF THE APPARATUS.

modified under the influence of agents capable of transforming the coloring matter of blood. In 1846, an English scientist, Stokes, in studying the phenomena of oxidation and reduction that cause arterial blood to pass to a venous state and *vice versa*, observed that the coloring matter of blood gave a different spectrum according as it was in one or the other of these states, and that the two oxyhemoglobine bands made way for a single band situated between them. This band, which is that of reduced hemoglobine, is named after its discoverer.

For researches on infinitesimal quantities of blood, one of our most distinguished chemists, Mr. Maurice de Thierry, Chemical Preparator to the Medical Faculty of Paris, independently of the apparatus called a hema-spectroscope, that he has already made known, makes use of an instrument that he has had constructed by Messrs. T. & A. Dubosey. This instrument, of great precision, which bears the name of the "great absorption spectroscope," was presented to the Academy of Sciences by Professor Cornu at the session of October 25, 1885. It permits of studying liquids filling a tube 30 feet long. The one which is figured in this place, and which is located at the Faculty of Medicine of Paris, and another like it at the Faculty of Sciences of Marseilles, is but 13 feet in length, and permits of observing a mass of liquid filling a tube 10 feet in length. It consists of three parts: (1) of a spectroscope, properly so called; (2) of tubes for containing the liquid to be studied; and (3) of an illuminating apparatus.

1. The spectroscope consists of a collimator, with a rectilinear slit situated in the focus of an achromatic objective; of a direct-vision and very dispersive prism; and of a telescope for observations. A small telescope, performing the functions of a collimator, is placed at the side of the spectroscope, and at right angles with its optical axis. This carries a transparent glass scale—the micrometer. This latter is reflected from the prism, and its image, returned to the telescope, becomes superposed with that of the spectrum. In the focus of the ocular there is a spider-thread reticule, which is fixed to a carriage moved by a screw. The thread, on being projected upon the image of the spectrum and upon that of the micrometer, permits, through its shifting, of very accurately measuring either the space existing between any two lines or bands, or the width of any one of them. In order to allow the entire length of the spectrum to be observed, the telescope is made movable around an axis that passes through the vertical plane of its objective.

2. The tubes are of two kinds, and are of inoxidizable metal lined with glass. At their extremities they are closed with glass disks, which have perfectly plane and parallel surfaces, and which are fastened on by means of movable ebonite collars. The tubes are in series of six: three of 3½ feet, one of 1·65 feet, one of 8 inches, and one of 4 inches.

3. The illuminating may be effected either by the electric or the Drummond light. In the apparatus illustrated herewith, a small oxyhydrogen lamp, affixed to the instrument, and provided with condensing lenses, gives the parallel rays that light up the tubes.

The frame consists of three varnished cast iron supports, 3½ feet in height, which carry two perfectly true semi-tubular lengths of iron connected with the supports by cross-braces that give the apparatus stability. These hollow pieces of iron have a total length of ten feet, and are designed to receive the tubes. The apparatus is so arranged, however, that the length may be extended to thirty feet and beyond, the length being limited only by the light, which, gradually becoming fainter on traversing the liquid under examination, would finally become insufficient with too long an apparatus.

One of the supports carries a hinged clamp in which the spectroscope is fixed through the extremity of the collimator, while in the center it is held by a leg. This latter also carries a gas-burner surrounded by metallic sleeve, provided with an aperture to allow the light to reach the micrometer. Under the spectroscope there is a double cock that permits the observer, without leaving his post, to turn on at will the light furnished by the oxyhydrogen lamp and the micrometer gas-burner. Long metallic tubes fixed upon the uprights lead the hydrogen and oxygen gases from the cock to the illuminating apparatus.

With this new apparatus, Mr. De Thierry has ascertained the presence of oxyhemoglobine in a liquid that contained but a hundred-millionth of it. The minutest quantities of ergotized rye mixed with common flour are at once detected, and the same is the case with chlorophyl. If the liquids are colored, the tube used depends upon the depth of the coloration. Upon the whole, this apparatus of high precision offers every guarantee of accuracy, and is capable of rendering great services, not only to legal medicine, but also to chemical biology and physics, through the study of the absorption spectra of liquids examined through long tubes.

Hereafter, examinations for blood, even when but traces of it exist, will be simpler and be effected more rapidly.—*La Nature.*

A NEW MEDICAL THERMOMETER.

THERMOMETERS, even when constructed with great care, are subject to errors that it is important to take into consideration. In time, the zero tends to rise, and its displacement may reach 2 degrees. In observation of the temperature of invalids, such variation causes considerable trouble. As a general thing, medical thermometers mark a higher temperature than they ought to. It is therefore absolutely necessary to frequently test thermometers in order to see whether their scale is accurate. But the medical thermometers in use are not adapted for such verification, since their scale always begins above zero and does not reach 100° C.

The thermometer figured herewith, however, is

capable of verification. The capillary tube is bent at C, and at TT' there are two $\frac{1}{5}$ degree graduations, separated by the double bend, C, and the small reservoir, *r*. The lower scale runs from −2° to +2°. The double bend prevents the re-entrance of the movable index, *i*, into the reservoir, *r*. This mercurial index gives the maximum.

In order to secure a perfect working of the instrument, it will suffice to plunge the reservoir, R, occasionally into a vessel containing cracked ice, and to observe the point at which the mercury stands still. If it stops above or beneath zero, the difference, whatever it be, must be taken into account in the final readings of the patient's temperature.

After each observation, a little shaking in a vertical direction will easily bring the index, *i*, back into the bend, C.—*La Nature.*

COCAINE IN SEA-SICKNESS.

DR. CHARLES F. MASON, Acting Assistant Surgeon, U.S.A., writes: "In a recent trip from New York to Norfolk by sea, I had an opportunity of observing, both in myself and others, the remarkable curative effects of cocaine in sea-sickness. The cases treated, four in number, were all adults, two being physicians. The symptoms in all were extreme nausea and great depression; no vomiting. Cocaine hydrochlorate, in doses of twelve minims of a four per cent. aqueous solution, afforded almost complete relief in from fifteen to thirty minutes, so that the three patients who were below were enabled to dress and come on deck. After a second half-grain dose (two hours' interval) the relief was complete and permanent."

PHOTOGRAPHY IN THE PULPIT.

THE following is from a sermon of Rev. G. Elder, reported in the *Christian Leader*: "Every heart is like a photographic plate. It is affected by the object which is placed before it from day to day. If that object is the world, the more worldly will the heart become; if it is self, the more selfish will the heart become; if it is impurity, the more impure will the heart become; if it is gold, the more covetous will the heart become. So every day the heart grows in likeness to the object set before it. And one day the judgment

will be pronounced: 'He that is unjust, let him be unjust still; and he which is filthy, let him be filthy still; and he that is righteous, let him be righteous still; and he that is holy, let him be holy still.'"

THE PHYSICAL APPEARANCE OF MARS IN 1886.

A SERIES of observations of Mars were obtained here in March and April last, with a 10 inch silver-on-glass reflector by With of Hereford. The powers employed were 252 and 475, but I found no advantage from the latter, which seemed too high for the purpose. As a rule, a single lens magnifying 252 was amply sufficient, though there were several occasions when a power of about 350 would have been a decided acquisition.

The planet came to opposition on March 6, but during the first three weeks of March we had intense frosts, and it was not feasible to commence observations until toward the end of that month. The opposition magnitude of Mars was only 16·6", so that as regards apparent diameter the planet was far from being favorably placed. At the opposition of 1877 the diameter was no less than 20·5". But at the recent opposition the north hemisphere of the planet (which has not hitherto been so thoroughly examined as the south hemisphere, and does not exhibit so many striking features) was well presented for observation, the latitude of the center of the disk being about 22° N. in March and April.

The markings seen were both numerous and diversified. There is evidently a mass of detail on the planet, which is, however, most difficult to trace out in reliable characters. Many faint lineaments reach the eye with sufficient distinctness to prove their existence, but they cannot be held steadily enough or with that perspicuity to allow of the delineation of their outlines, or to enable their relative positions to be correctly assigned. Only the more pronounced features can be drawn satisfactorily. The small diameter of Mars during the recent observations has in a great measure induced this uncertainty as to the physical aspect of the disk. Another cause is found in the rarity of really good telescopic images. Not only must the atmosphere be peculiarly favorable to sharp definition, but there must be an absence of wind. A complicated system of markings cannot be made out under the influence of annoying vibrations. Moreover, this planet, considered as a telescopic object, is far less satisfactory than either Jupiter or Saturn, and this circumstance, with the other drawbacks alluded to, have given rise to that uncertainty, and to many of the discordances, in regard to the visible markings observed on his surface.

My intention in the present paper is merely to describe general results, as a particular description would scarcely be intelligible without drawings. Between March 23 and April 30 the planet was examined on twenty-one evenings, and a considerable number of sketches were completed. During the period mentioned the weather afforded an unusual number of clear nights, and whenever the seeing was fairly good the visible features were carefully noted, the results being afterward compared with each other and with former work in the same direction. My drawings correspond very closely among themselves, and there is a fair agreement in the main features with those depicted on the charts of Green, Schiaparelli, Knobel, and others. I have also compared them with the views given in Terby's work on Mars and with Boeddicker's drawings of 1881 and 1884 (with Lord Rosse's 3 foot reflector), published in the scientific *Transactions* of the Royal Dublin Society, and find in many instances a substantial confirmation. Some of the differences are larger than would have been considered probable, but experience has taught us that it is useless to expect uniformity in delineations of planetary details.

During the five weeks over which my observations extended, I saw no conclusive evidences of physical changes in any of the markings. But the period was too limited, and the circumstances affecting the review altogether too unfavorable, to enable me to speak definitely on this point. The slight differences apparent among my drawings are merely such as were occasioned by changes in local atmospheric conditions. On a bad night faint markings, previously distinguished, would appear obliterated, and on thoroughly good nights I saw delicate appearances which were utterly beyond reach on less auspicious occasions. I am convinced that these changes in the character of the seeing exercise great influence on the distinguishable features of a planet; more so, in fact, than observers usually concede. Inferences of real change are sometimes hastily adopted in consequence, but they can only be substantiated after the most searching examination and the most convincing proofs.

The exterior edges of many of the well defined seas on Mars are very brilliant, and their boundaries very definite. These brilliant, outlying borders remind one of the light areas often abutting on the dark spots of Jupiter, only in the case of Mars they are more extensive, more permanent, and altogether dissimilar in form. I may instance a particular case of this bright bordering in the immediate region east of the Kaiser Sea on Mars. On several occasions this was so striking as to vie with the bright patch about the north pole. This shimmering extends several degrees east of the dark outline of the sea, but is limited by a faint and irregularly condensed marking extending northward, with an inclination east, from the knot in longitude 290° just east of the north extremity of the Kaiser Sea, as figured in Mr. Green's chart. This marking runs over a considerable tract, and its east extension underlies Davies' forked bay and Burton Bay, to both of which it is connected by faint ligaments of shade, reminding one of the "canals" of Schiaparelli. This special marking, which is not included in Mr. Green's map, may be identical with the network of dark narrow streaks figured in this region by Schiaparelli in his chart for January and February, 1882. It is also more or less definitely shown in some other drawings, notably on one by Schmidt, which forms No. 17 in Dr. Terby's Areography.

As to the Kaiser Sea, it appears very faint and narrow, if not really broken, in the region some 10° or 15° south of its north extremity. This peculiarity is well drawn in Herr Boeddicker's drawings of December 27, November 19, and December 26, 1881 (Nos. 11, 13, and 14), in the scientific *Transactions* of the Royal Dublin Society for December, 1882. Consulting other drawings, I cannot find that this feature is sufficiently indicated. It is obvious, however, that it would only be well detected when placed near the apparent center of the disk, as during the recent opposition.

Mr. Knobel's drawings in 1873 (*Monthly Notices*, vol. xxxiii., facing p. 476) agree generally with mine far closer than those he has published in the *Memoirs*, vol. xlviii. part ii., 1884. I always see Knobel Sea on Green's chart separated on its south side from the fainter curving band running east, as in the sketches Nos. 6, 7, 8, and 9, 1873. This break is not depicted in the subsequent drawings of 1884, so that the appearance has either been subject to actual variation of aspect or the difference of inclination has originated the want of uniformity. Probably the latter is the real cause, for the inclination of Mars in April and May, 1873, was nearly identical with that of March and April, 1886, and it is for these periods the drawings are so nearly alike in their more conspicuous forms. I see the northern boundary of Knobel Sea distinctly separate from the dark longitudinal strip immediately contiguous to the north polar cap.

The drawing No. 12, May 19, 1873, by Mr. Knobel, portrays the leading features of this region much as I have more recently observed them. In 1884, Mr. Knobel delineated the whole mass of shading outlying the north pole as blended uninterruptedly, but these differences are unquestionably due to the changes of inclination, which must necessarily introduce such discordances into the apparent forms of the markings as observed at different epochs.

As to the canal-shaped features of Schiaparelli, first seen in 1877 and 1878, and subsequently confirmed, I have distinguished a large number of appearances highly suggestive of such a configuration, but the Italian drawings made during the three months from October, 1881, to February, 1882, give them a definite character and (apart from their duplication) a straightness of direction and general uniformity of tone which my observations do not confirm. The more delicate and complex markings on the planet appear to my eye, under the best circumstances, as extremely faint, linear shadings with evident gradations in tone, and irregularities occasioning breaks and condensations here and there.

If they existed under the same aspect and with the same boldness as delineated by Schiaparelli, they would have been readily detected here whenever the seeing was fairly good, for these objects are referred to as readily observed in the 8 inch refractor of the Milan Observatory in February, 1882, when the planet's diameter was only 13".

The duplication of these lines was also traceable under the same unfavorable conditions. The wonder is, not that the eminent Italian astronomer has discovered such a marvelous extent of curious detail on this planet, because this detail unquestionably exists, though scarcely in the form and character under which it is represented, but that he should have observed its more complex and difficult configuration at the very period when Mars was so very unfavorably situated for observations of this critical nature.

The surface markings of this planet are so numerous and varied that they are far from being adequately represented on existing charts. In certain regions the disk is so variegated as to give a mottled appearance. Dark lines and spots and bright spaces are so thickly interspersed, and so difficult to observe with sufficient steadiness to estimate their positions and forms, that I found it impossible to make thoroughly satisfactory drawings. An observer has to be content with endeavors to depict the more prominent marks only; and even in connection with these there is always some element of uncertainty. The rotation-period of the planet is, however, so slow, the hourly rate being only 14·6" in comparison with 36·7" in the case of Jupiter, that plenty of time is afforded for drawing the leading markings before they show a displacement obvious to the eye In addition to this, a drawing of Mars may be made to rest on several successive evenings of observation if the observer comes 37·4 min. later to the telescope on each occasion. In regard to Jupiter, the difficulty of suitably drawing the details is far greater, though they admit of more ready observation. The rapid rotation of this planet displaces objects in a few minutes, and makes it imperative that the work both of observing and charting should be very hastily performed; and it is not feasible in this case to base a sketch on observations of following nights, because the markings are influenced by different velocities, and suffer large relative displacements even at short intervals of time.

During the past few months the north polar cap of Mars has been very bright, sometimes offering a startling contrast to those regions of the surface more feebly reflective. Some of the other parts were also notably brilliant. These luminous regions of Mars require at least as much careful investigation as the darker parts, for it is probably in connection with them that physical changes (if at present operating on the planet's surface) may be definitely observed. In many previous drawings and descriptions of Mars, sufficient weight has not been accorded to these white spots.

Many of our leading treatises on astronomy attribute a dense atmosphere to Mars, but nothing has been observed during my recent observations to corroborate this theory. It seems to me far more plausible to assume that the atmosphere of this planet is extremely attenuated. The chief spots are invariably visible, and the phenomena occasionally observed are rather to be imputed to the vagaries of our own atmosphere than to that of Mars. Jupiter and Saturn are doubtless envelcped in dense vapors shrouding their real surfaces from terrestrial eyes. Their markings are atmospheric, though in some cases very durable, and constantly undergoing changes of aspect and displacements of position by longitudinal currents. On Mars a totally different nature of things prevails. Here the appearances descried are absolute surface markings displaying none of the variations which are so conspicuously displayed in the markings on Jupiter. It is probable that many, if not all, the changes supposed to have occurred in the features of Mars are simply attributable to the constantly varying conditions under which the planet has necessarily to be observed. Were the circumstances of observation more equable, there would be much greater unanimity among observers of this interesting object. It seems to me that the very pronounced character of the markings and their great permanency are quite opposed to the idea that the planet is surrounded by a dense, cloud-laden atmosphere.—*W. F. Denning, in Nature.*

THE "CANALS" OF MARS.

M. TERBY, in a note presented some little time ago to the Royal Academy of Belgium, drew attention to the occurrence in the drawings of Mars made by Herschel and Schroeter of several markings resembling the well-known Kaiser Sea in size and distinctness, and pointed out that M. Schiaparelli, in his observations of 1881–82, represented the "canal" Indus as developed to dimensions almost as great as those of the Kaiser Sea, and that this development coincided with the "geminations" or doubling of almost all the other canals. M. Faye now announces at the last meeting of the Académie des Sciences that M. Perrotin and the other observers at the Nice Observatory have recently been able to redetect M. Schiaparelli's canals. The reality of the existence of the delicate markings discovered by the keen-sighted astronomer of Brera seems thus fully demonstrated, and it appears highly probable that they vary in shape and distinctness with the changes of the Martial seasons.

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